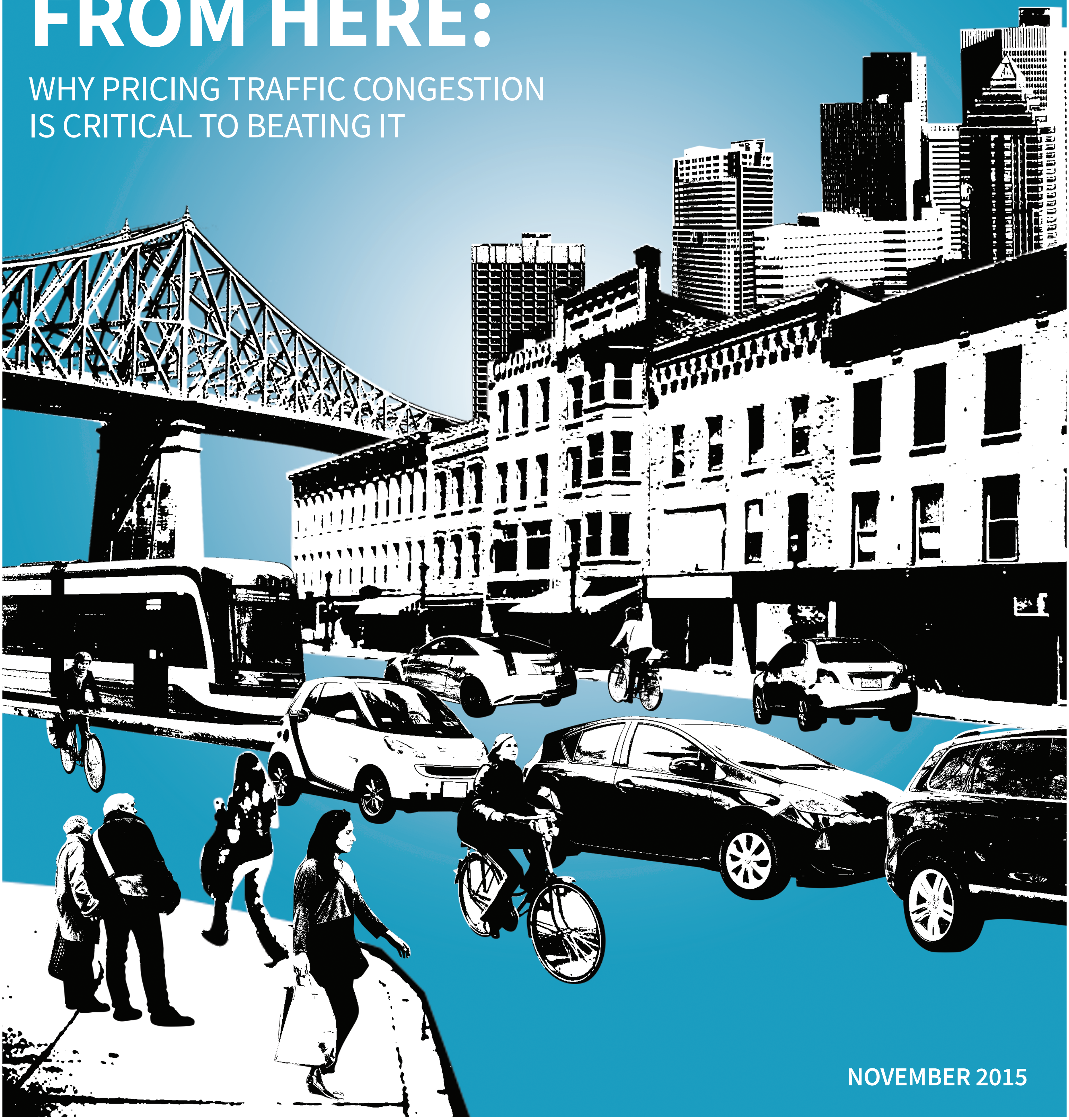
CANADA'S **ECOFISCAL** COMMISSION
Practical solutions for growing prosperity

WE CAN'T GET THERE FROM HERE:

WHY PRICING TRAFFIC CONGESTION IS CRITICAL TO BEATING IT



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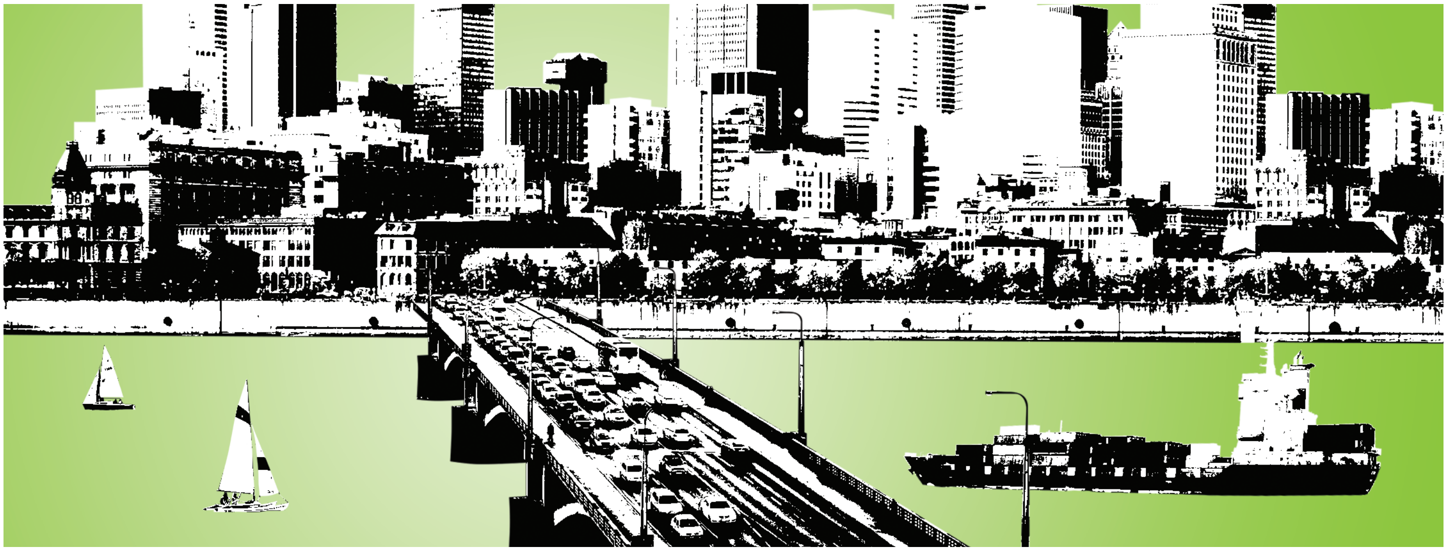

CANADA'S ECOFISCAL COMMISSION

WHO WE ARE

A group of independent, policy-minded Canadian economists working together to align Canada's economic and environmental aspirations. We believe this is both possible and critical for our country's continuing prosperity. Our Advisory Board comprises prominent Canadian leaders from across the political spectrum.

We represent different regions, philosophies, and perspectives from across the country. But on this we agree: ecofiscal solutions are essential to Canada's future.

OUR VISION

A thriving economy underpinned by clean air, land, and water for the benefit of all Canadians, now and in the future.

OUR MISSION

To identify and promote practical fiscal solutions for Canada that spark the innovation required for increased economic and environmental prosperity.

For more information about the Commission, visit **Ecofiscal.ca**

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EXECUTIVE SUMMARY

Traffic congestion is a growing problem in many of our cities, imposing significant costs on Canadians

Congestion on our roads and freeways leads to wasted time for commuters and goods movement. Given the importance of the movement of goods and people through our cities, this lost time translates into a less efficient economy. The Toronto Board of Trade (2013), for example, estimates that the direct annual costs of congestion for the Greater Toronto and Hamilton Area could rise to $15 billion by 2031 without further action. In some Canadian cities, it takes more than an hour to get to and from work every day for half or more of the residents. Congestion also affects choices about where to live, undercutting the ability of cities to attract businesses, jobs, and workers. And congestion increases air pollution from vehicles, with corresponding health implications for Canadians. This air pollution is related to higher risks of asthma, high blood pressure, cardiovascular disease, diabetes, aggravation, and stress.

As cities continue to grow, with higher levels of urbanization and car ownership, traffic congestion and its associated costs are expected to worsen. The higher these costs climb, the greater the benefits from reducing congestion.

Congestion pricing is an essential—but missing—piece of smart transportation policy

Congestion pricing is an ecofiscal policy that prices road use or parking with the aim of reducing costly traffic congestion. A growing body of evidence and policy experience suggests that congestion pricing works, particularly as part of a broader policy package. When designed well, it leads to reduced traffic congestion and creates net economic benefits both for the economy as a whole and for individual drivers.

The case studies examined in this report highlight this point: pricing policies of different kinds have reduced congestion. In Ontario, traffic on the tolled Highway 407 consistently moves at free-flow speeds, while peak travel times on parallel unpriced routes are 50% to 200% longer. Under Stockholm's congestion pricing policy, vehicles entering the city core dropped by 20% to 30%. Minnesota's high-occupancy toll (HOT) lanes increased traffic speeds by 6% in the general-purpose lanes while maintaining free-flow speeds in the toll lanes. In Oregon's pilot project, drivers subjected to higher per-mile charges during peak times responded by reducing driving at those times by 22%, relative to those paying a flat rate. And San Francisco's parking-pricing program led to a 50% decline in the number of drivers circling for a parking spot—a major contributor to downtown traffic congestion.

Despite the evidence of its potential benefits, Canada has very limited experience with congestion pricing. The traditional approach to dealing with traffic congestion has been to expand public transit and build more roads. These policies are key components of the transportation puzzle: they increase the overall capacity of the transportation system and can reduce congestion in the short term. In the absence of congestion pricing, more drivers will ultimately fill this increased road capacity, and congestion may not be reduced in the long term. Moreover, the building of new road infrastructure to meet growing demand is constrained by land-use policy and increasingly stretched government budgets.

Congestion pricing is therefore the crucial, missing piece of a broader, coordinated package of policies to create greater mobility for a growing urban population. More public transit, roads, and cycling infrastructure provide drivers with alternatives, making it easier for them to respond to the congestion price by changing their behaviour. They are essential complements to congestion pricing. But without addressing the fundamental issue of misaligned incentives around free access to roads, traffic congestion in Canadian cities will only get worse.

The design details of congestion pricing policy matter

Congestion pricing is not a one-size-fits-all policy solution. Different cities face different types of congestion problems, and tailoring policies to local circumstances is critical for success. Policy design includes a range of choices. Should pricing be narrowly targeted or broadly applied? That is, should it price access to some roads, to all roads, to parts of roads, or even to parking? How should the price vary? Should it be higher at times of peak traffic, or even vary dynamically in response to real-time traffic levels? How should revenue from the policy be used? Smart policy design can reduce congestion, improving efficient transportation and travel outcomes for all travellers. It can also ensure that low-income travellers are not disproportionately affected. But the specific details of effective, cost-effective, fair, and practical policy solution will vary from city to city.

How can we move ahead with practical and cost-effective policy to reduce traffic congestion while considering the unique and complex characteristics of each city? This report makes four recommendations for Canadian policymakers.

RECOMMENDATION #1: Major Canadian cities should implement congestion pricing pilot projects, customized to their local context

As illustrated by case studies from Stockholm, Oregon, and San Francisco, trial periods for congestion pricing are low-risk policy initiatives. They can be voluntary for drivers, as in Oregon; take place for a limited time, as in Stockholm; and apply to a narrow scope of drivers, as in San Francisco.

Yet the benefits of such trials could be huge. If well designed, they can demonstrate the concrete benefits that congestion pricing can deliver. They can also provide opportunities for learning about how well different policy designs work in different contexts, thus allowing policy design to evolve and improve over time.

Municipalities best understand their own congestion context, and should play a major role in designing pilot projects. They should design their pilot projects according to their unique policy objectives and their local geography, governance, infrastructure, and attitudes and cultures. Different trial policies are not only more likely to succeed when customized to local context, but can also provide more information to other Canadian cities regarding what works and what does not.

The four proposals for congestion pricing policies for each of the country's four largest cities outlined in this report could form the foundation for time-limited trials in each city. The details of each proposal draw on lessons that emerge from experience with congestion pricing in other jurisdictions, take into account local context (gauged in part from interviews and polling), and consider key elements of policy design. They are not recommendations in and of themselves, but instead are intended as policy springboards to kick-start more detailed policy conversations in each city.

- **Metro Vancouver** has constrained geography bounded by mountains and ocean, polycentric travel patterns with multiple hubs of activity, and a complex governance structure with involvement from multiple municipalities and the provincial government. Applying variable pricing to each of the region's bridges and tunnels that cross waterways would be one way to price access to key driving arteries to reduce regional congestion.

- **Calgary** has low density, a lack of familiarity with congestion pricing, and more localized congestion problems. In this context, HOT lanes could be practical to implement, provide unpriced alternatives, and reduce congestion in key locations.

- The **Greater Toronto Area** has polycentric travel patterns with drivers travelling between multiple hubs in multiple directions and relatively unconstrained geography. Converting high-occupancy vehicle (HOV) lanes to HOT lanes or building new HOT-lane capacity on the provincially owned 400-series of highways—a backbone of the regional transportation network featuring the privately operated and variably tolled Highway 407—would be a practical approach for reducing congestion in the area.

- **Greater Montreal** has extensive commuting to and from the central Island of Montreal; relatively widespread congestion; an existing, time-varying toll on the Autoroute 25 bridge connecting the Island; and plans to replace—and toll—the aging, highly used, and federally owned Champlain Bridge. The natural cordon formed by the Island provides a practical opportunity to implement variable pricing on the full array of surrounding bridges and tunnel, harmonizing tolls and reducing congestion throughout the area.

RECOMMENDATION #2: Provincial governments should initiate, enable, or facilitate congestion pricing pilot projects

Provincial governments can play multiple roles in enabling congestion pricing. First, not all roads are municipally owned and operated. In some situations, it is provincial governments that should directly implement congestion pricing policies. We consider approaches for Toronto, for example, that would price access to all or some lanes on the provincially owned 400-series freeways. While coordination with municipal government would be essential, the province should implement the congestion pricing policy.

Second, provincial governments should play a coordinating role. A key governance challenge in many urban areas (for example, Metro Vancouver and Greater Montreal) is the diverse collection of municipalities with highly linked and overlapping transportation corridors.

Finally, provincial governments should provide municipalities with explicit authority to implement congestion pricing policies. The existing legal framework for implementing road pricing in Canadian municipalities is unclear, and is complicated by overlapping jurisdictions. Generally, most municipalities are unable to implement broad congestion pricing on their own without changes to provincial policy. Provincial governments should reduce the existing ambiguity and make space for municipal policy by passing explicit legislation permitting municipalities to implement these policies.

RECOMMENDATION #3: The federal government should help fund pilot projects

Funding for congestion pricing pilot projects remains a barrier. Physical and digital infrastructure will be required to set up, monitor, and enforce the pricing policy during the trial period. While revenue could be generated, the scale of this revenue is uncertain and depends on the details of how the policy is implemented. Municipalities have very limited revenue sources and could face significant financial challenges in initiating pilot projects.

Federal funding to establish pilot projects would generate benefits for Canadians well beyond the individual municipalities involved. Evaluation of these projects would lead to valuable lessons learned about congestion pricing policy design and implementation that could be applied in other Canadian cities. Additionally, the cross-country benefit of efficient goods movement means that the federal government has a direct interest in supporting regional congestion pricing.

Support from the U.S. federal government played an important role in at least two of the American case studies examined in this report. Federal support helped enable the parking-pricing trial period in San Francisco as well as helped finance the development of Minnesota's HOT lanes.

RECOMMENDATION #4: Governments should carefully evaluate the performance of pilot projects, communicate the results broadly, and incorporate lessons learned into future mobility policies

The full benefits of pilot projects can only be realized if they are monitored over time, with data from before and after a project is implemented. The projects should be set up so that the impact on congestion, and also the overall administrative costs, can be measured and assessed. This analysis can help to communicate new, city-specific information about the efficacy of congestion pricing to stakeholders and to the general public. Demonstrating policy success can be a powerful tool for building public support.

This data-driven evaluation of the policy should be used to inform next steps. If the policy does not perform as well as anticipated, its design can be adjusted over time to respond to problems, or the policy can be terminated. If, on the other hand, the policy performs well, it can be expanded more broadly. Both the benefits and the costs of the policy should inform subsequent policy decisions.

Pilot projects are only a first step in addressing Canada's congestion problems. Yet as cities grow and congestion problems build, a starting point for smart policy is desperately needed. Demonstrating the effectiveness of congestion pricing on a small scale can create a launching pad for creating a transportation system that gets prices right—a transportation system that fosters cleaner air and more liveable cities, and ensures people and goods move efficiently, rather than wasting time in traffic.

CONTENTS

1 INTRODUCTION

Congestion pricing is the missing piece in our cities' transportation puzzles. Traffic congestion imposes major costs—on commuters, on the environment, on business, and on the economy as a whole. However, the majority of Canadian cities have yet to move forward with the policy change most fundamental to reducing traffic congestion. This report explores how congestion pricing can lead to clear economic benefits for drivers, commuters, riders of public transit, and business owners when it is designed with local context in mind.

The costs of traffic congestion are mounting as the rising number of drivers puts more stress on our existing roads. Congestion imposes costs on individual drivers in terms of lost time and income. And it has much broader economic implications since transportation is fundamental to the efficient functioning of a modern economy. Congestion also incurs environmental costs, as it increases air pollutants from vehicles, with implications for air quality and human health. Along many dimensions, traffic congestion reduces the overall liveability of our cities.

As congestion problems grow, governments are increasingly paying attention. In 2015, Toronto Mayor John Tory, Vancouver Mayor Gregor Robertson, and Gatineau Mayor Maxime Pedneaud-Jobin noted that about 80% of Canadians now live in cities that face crippling congestion and failing infrastructure (CBC News, 2015).

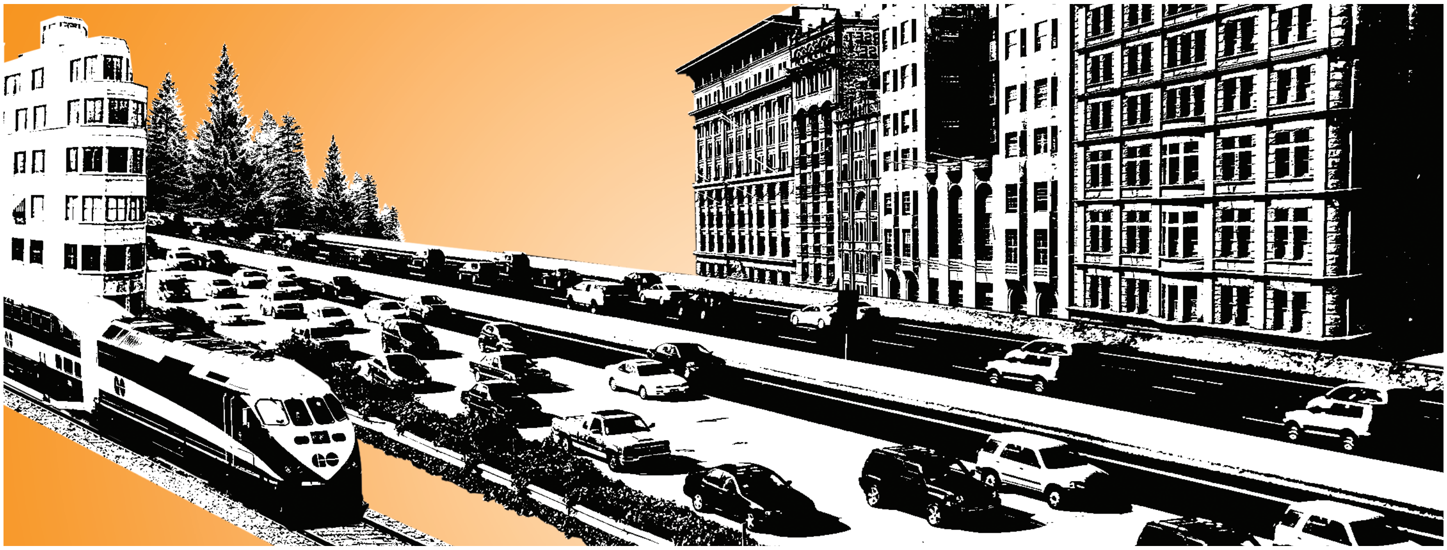
Despite the growing problem, however, congestion pricing seems to be the one key policy element not being sufficiently discussed. Investing in public-transit capacity and building additional roads are important and can help move more goods and people through our cities. But on their own, these expenditures cannot solve the problem over the longer term: more road capacity and infrastructure lead to more driving and, eventually, more traffic congestion.

Ecofiscal policies, on the other hand, can successfully address the central problem. Putting a price on congestion leads to reduced traffic and clear economic and environmental benefits, as illustrated by several international case studies discussed in this report. In many parts of Canada, congestion pricing is the missing piece of an integrated approach to reducing congestion.

As always, however, the details of policy design matter. Different policies can price traffic congestion in different ways. And different cities face different circumstances: they vary in their geography, public governance, existing infrastructure, and socio-economic characteristics. How can such policies be best designed and implemented for individual Canadian cities?

The objective of this report is to explore how different pricing approaches can reduce congestion in our cities. As part of the research underpinning the report, we interviewed government and transit officials as well as a set of congestion experts in four of Canada's largest cities. These interviews ground our analysis in city-specific context by identifying the major priorities, the most promising policy solutions, and the likely barriers to policy advancement.

The remainder of this report is structured as follows: Section 2 lays out the costs of traffic congestion, explains the essence of congestion pricing policy, and describes its advantages relative to other policy tools. The main types of pricing instruments are examined in Section 3, where we use five case studies to illustrate lessons from experience. Section 4 provides an overview of considerations for designing appropriate congestion pricing policy, exploring trade-offs between different design choices. We apply this framework in Section 5 to four cities— Metro Vancouver, Calgary, the Greater Toronto Area, and Greater Montreal—and consider how unique characteristics within each might lead to particular policy choices. Section 6 outlines some important general principles for jurisdictions considering implementing pricing policies. Finally, Section 7 recommends that the country's governments—with support from all three levels—move forward with pilot projects to demonstrate the benefits of well-designed, locally customized congestion pricing policy.



2 CONGESTION: A COSTLY PROBLEM WITH AN ECOFISCAL SOLUTION

Traffic congestion is an increasingly urgent economic, environmental, and social challenge for our cities, and for Canadians more generally. We should certainly recognize that well-used roads are signs of a vibrant and dynamic economy; they also reflect the high value individuals place on their freedom of mobility. But when too many people take to the roads, the ensuing stop-and-go traffic is an economic drag that erodes the liveability of our cities. This report focuses on excess congestion: the point at which travel speeds drop below efficient levels—where the private and social costs of road congestion outweigh the benefits to drivers.

2.1 TRAFFIC CONGESTION IS COSTLY FOR CANADIANS

Excess traffic congestion is costly for several reasons. It takes valuable time away from drivers, but also from other road users, such as passengers of public transit. Congestion increases the cost of commercial transport, thus increasing the prices of goods and services for everyone, regardless of where they live. It also contributes to air pollution, increases greenhouse gas emissions (GHG), and increases the number of accidents with resulting injuries, property damage, and death.

Lost time and productivity are the biggest costs of congestion

Research by Transport Canada (2006a) finds that between 79% and 94% of the total costs of congestion for passenger vehicles are attributable to time delays, varying across urban areas and depending on details of traffic flows.[1] In addition to travel delays, traffic congestion reduces the reliability of travel time (Small & Verhoef, 2007). Unpredictable and variable travel times require drivers and transit users to build more time into their schedules to avoid being late. Accordingly, people stand to benefit not only from reductions in average travel times, but also from improvements in travel-time consistency. Both recurrent congestion (i.e., traffic occurring at consistent times and locations) and non-recurrent congestion (i.e., traffic due to road maintenance or accidents) impose significant economic costs (Hall, 1993; Transport Canada, 2006b).

Congestion can also lead to forgone trips, imposing important

[1] Although the Transport Canada study did not include many of the environmental and health costs (discussed below), research in the United States suggests that these costs are significantly smaller than the economic costs of congestion (Levy et al., 2010).

"hidden" costs. For example, unpredictable or long commutes can make working at a particular location less attractive, leading workers to take poorly suited jobs and companies to hire less-qualified employees. And if businesses relocate as a result of traffic congestion, they may incur costs from being farther from key markets or clusters of business and innovation. Recent reports estimate these annual hidden costs for Metro Vancouver and the Greater Toronto and Hamilton Area from $500 million to $1.2 billion and $1.5 billion to $5 billion, respectively—at least as large as the direct costs from delay (Dachis, 2013, 2015).

In absolute terms, Greater Montreal, Greater Toronto and Metro Vancouver stand out as having the most significant congestion problems when it comes to delays and unpredictable commuting times. Studies for Greater Toronto, Greater Montreal and Metro Vancouver indicate that congestion imposes direct annual costs of roughly $7 billion, $1.7 billion and $1.4 billion (in 2015 Canadian dollars), respectively (Chambre de commerce du Montréal métropolitain; HDR Inc., 2008, 2015). Costs in Toronto could rise to $15 billion annually by 2031 without further action (Toronto Board of Trade, 2013). These estimates do not include the previously mentioned hidden costs. Similar estimates have been conducted for other Canadian cities, but because the estimates use different methodologies and are based in different years, meaningful comparisons across cities are difficult, as discussed in Box 1.

Finally, traffic congestion is not just a problem in Canada's largest cities. Levels of urbanization and car ownership are increasing across the country, and all cities are facing significant infrastructure constraints (Felio, 2007). Indeed, when congestion costs are considered on a per capita basis, all Canadian cities—big and small—deal with a similar problem.

Traffic congestion is also costly for business

While the effects of traffic congestion on personal mobility are mainly a problem in large urban centres, delays from congestion for commercial transportation impact all Canadian businesses and consumers—even those living in remote communities. Approximately 90% of the goods we consume on a daily basis are transported by truck, and demand for just-in-time delivery creates increased pressure for timely and reliable shipments (Canadian Trucking Alliance, 2015).

Delays in product movement impact Canadians both directly and indirectly. Consider these examples. A plumber stuck in traffic while a client waits with a leaking pipe illustrates a very direct and upfront cost, for both plumber and client. A truck driver encountering consistent delays transporting steel to a construction project or a wholesale food supplier delayed in delivering perishable goods to a grocer illustrates a situation where costs for the final product are increased indirectly by the traffic congestion.

In fact, congestion affects goods transport even more than it does commuters. Unlike drivers of passenger vehicles who

Box 1: Congestion Costs Are Difficult to Quantify and Compare Across Cities

Attempts to quantify the total costs of congestion are complex and vary substantially in methodology, each with advantages and drawbacks.

One method for estimating travel delays from congestion is to define a congestion threshold—a baseline percentage of free-flow speed that is deemed acceptable (approximately 50% to 70% of the posted speed limit), and define congestion as travel occurring below this speed threshold (Lindsey, 2007). An alternative approach is to determine a socially optimal level of traffic flow in urban areas, and accordingly a level of congestion that balances the benefits of a high volume of movement with the costs of reduced mobility (Litman, 2015a).

Attempts to measure the total or per capita economic, social, and environmental costs of congestion are fraught with difficulties. The study by Transport Canada is one of the best attempts at valuing Canada's congestion costs and illustrates some of the biggest methodological challenges (Transport Canada, 2006a, 2006b). The study focused primarily on the economic costs, including time delays, wasted fuel, and GHG emissions. Owing to data limitations, the study did not include other social or environmental costs, such as the health impacts from air and noise pollution or the wider economic impacts from congestion. The study also only focused on passenger vehicles and did not include the (higher) costs to commercial vehicles. Estimates in different cities were also based in different years, making cross-city comparisons difficult.

Table 1: The Business and Economic Impacts of Congestion for Supply Chains[2]

Type of Impact	Business and Economic Implications of Congestion
Market and Fleet Size	• Shrinks delivery area served by shippers • Necessitates more commercial vehicles, drivers, total trips • Creates greater unpredictability of shipping routes • Increases delivery costs, including labour and fuel
Delivery Schedules	• Reduces late-afternoon deliveries owing to heavy congestion • Forces truck shipments to start and end earlier in the day
Intermodal Connections	• Leads industrial parks to move farther from urban cores to avoid congestion, increasing total number of freight vehicles and average trip distance • Increases missed or delayed deliveries at ports, resulting in additional costs
Business Inventory	• Increases inventory requirements and potential loss in sales • Reduces cross-docking opportunities (matching incoming with outgoing deliveries) • Increases inventories for businesses with "chronic delivery problems"
Business Location	• Affects access to labour markets and freight-delivery markets • Affects location of distribution and production centres

typically have greater flexibility in choosing the time and route of their journey, truckers and businesses often face inflexible delivery schedules (Holguín-Veras, 2008). With fewer options to avoid congested roads, the commercial-goods sector is on the front line of traffic congestion in Canadian cities.

Estimates of the value of time for commercial goods movement range from $40 to $210 per hour per truck (in 2015 Canadian dollars), depending on the vehicle size and whether both direct and indirect costs are included (Ismail et al., 2009). When added together, the costs of wasted time, missed deliveries, and lost productivity from congestion imposes high and often overlooked economic costs for Canada's commercial-goods sector. Unpredictable and unreliable travel routes add to these costs, as businesses must provide larger buffers and carry more inventories to minimize the impact of delivery delays (Grant-Muller & Laird, 2007).

Traffic congestion is also deeply rooted in business decision-making: freight-dependent businesses locate in a particular region partly due to travel time and the reliability of serving markets and sourcing inputs. In one form or another, the costs for commercial-goods movement are significant and widespread, and are ultimately passed on to consumers in the form of higher prices. A study of trucking companies by the Washington State Department of Transportation suggests that consumers bear approximately 60% to 80% of these costs (Government of Washington State, 2012). Table 1 summarizes some of the effects from congestion for the commercial-goods sector.

Congestion exacerbates environmental and health costs

In the case of an uncongested road, the major social costs from driving consist of road maintenance costs, GHG emissions, local air pollutants, noise, and accident risk. Congestion amplifies each of these costs by increasing the amount of time a vehicle is on the road. Vehicles are also less fuel-efficient when travelling at slow speeds and thus emit more exhaust.

Many Canadians are affected by congestion even if they do not drive. In a 2013 report, Brauer et al. highlight that one-third of the Canadian population live in areas near highways or major urban roads and are exposed to traffic-related air pollution and the consequent health risks. Tailpipe emissions from vehicles are a significant source of hazardous air pollutants, such as sulphur dioxide, nitrogen oxides, volatile organic compounds, carbon monoxide, and particulate matter. When emitted in large concentrations, these pollutants

[2] Summarized from Weisbrod and Fitzroy (2011).

react together to form smog and ground-level ozone.

Air pollution from vehicles is related to higher risks of asthma, high blood pressure, cardiovascular disease, diabetes, and stress (Brauer et al. 2013). Smog and ground-level ozone are associated with higher rates of respiratory and cardiovascular problems, cancer, and reproductive problems (Levy et al., 2010). Air pollution from the transportation sector affects human health, leading to costs across Canada with an estimated economic value of between $5 billion and $9 billion (in 2014 dollars) annually (Sawyer et al., 2007).

The effects of air pollution on infants and children are striking. Long-term exposure can result in impaired lung development, low birth weight, preterm pregnancy, childhood leukemia, and premature deaths (Environmental Protection Agency [EPA], 2015). In comparing children living in areas with high levels of vehicle emissions with those in low-emissions areas, research suggests that children from high-emissions areas are, on average, more likely to score lower on intelligence tests and are more prone to a wide range of psychological problems (Hotz, 2011).

Accident risk, and the associated health-care cost, is also magnified by traffic congestion. Litman (2015b) shows that in cities such as Stockholm, Tokyo, London, and New York—affluent and compact cities with strong transportation demand-management strategies—fatality rates are approximately one-third the rates of affluent, compact cities *without* strong strategies to manage transportation resources, and one-sixth the rates of affluent but sprawling and automobile-dependent cities. Similarly, Green et al. (2014) find a 38% to 40% reduction in vehicle accidents in central London as a result of that city's congestion pricing policy.

In addition to the health effects, tailpipe emissions adversely impact ecosystems and agriculture. Air pollution damages vegetation, soil, water, and wildlife, and can also stunt agricultural yields and timber growth (Environment Canada, 2014a). Traffic congestion intensifies each of these negative impacts from driving.

The incremental tailpipe emissions from road congestion are also connected with climate change, albeit on a small scale. As a result of slower-moving vehicles, longer traffic lineups, and more fuel being burned, traffic congestion increases the total release of GHG emissions. Using estimates of wasted fuel from Transport Canada (2006a), GHG emissions from congestion accounted for approximately 0.2% of Canada's total emissions in 2011 (Environment Canada, 2014b).

2.2 A NEW KIND OF POLICY SOLUTION IS NEEDED

Given these costs, what is the long-term solution to ensure that Canadian prosperity is not continually held up in traffic?

Multiple factors lead to excess congestion

Traffic congestion is the result of various related factors. Urban design and transportation infrastructure are shaped by a city's historic development, and can lead to inefficient spacing of trip origins and destinations. Populations are increasing in our major cities, along with the number of vehicles on the road (Statistics Canada, 2015a). Suburban sprawl compounds these trends, placing greater distances between where people live, work, and play, and creating greater pressures on road networks (Statistics Canada, 2008). In many cases, alternative modes of mobility, such as public transit, walking, and cycling, may be impractical or unavailable.

Taken together, these factors lead to longer trips, greater use of road space, higher interference between vehicles, and slower traffic flows. Fundamentally, however, these problems stem from the fact that road access is underpriced. Drivers' incentives to use roads, and the full costs of their road usage, are misaligned.

Misaligned incentives are the source of congestion

Road use has traditionally been freely available to anyone with a driver's licence, and the open-access nature of roads makes them vulnerable to overcrowding. As discussed above, individual road use can lead to lost time, wasted fuel, increased air pollution, and increased accident risk (Anas & Lindsey, 2011). Each driver's presence imposes costs on all others, and the pollutants from each car impose costs on all people who breathe the air. Yet drivers are not bearing the full costs associated with their actions.

Traffic congestion therefore has a lot more in common with pollution than many might think. The actions of individuals—behaving according to their private interests—impose costs on other members of society. Free access to roads means that they are overused. In short, congestion is a problem ideally suited for an ecofiscal solution, one that adjusts market prices to fully reflect social costs.

Another perspective of this problem sees public expenditures on road building and maintenance as implicit subsidies to drivers. If government provides open-access roads using general revenues, as is usually the case, non-driving taxpayers are essentially paying for infrastructure that benefits drivers. These implicit subsidies distort the relationship between commuting costs and housing costs, and encourage urban sprawl. Because transportation infrastructure is often financed from general revenues, it makes the cost of commuting artificially low for people seeking to live on the periphery of cities (Bazel & Mintz, 2014). This exacerbates congestion (and other social and environmental problems) by creating a need to commute longer distances and thus an excessive demand for transportation infrastructure (Litman, 2015a).

Taxes on fuels play a key role in transportation investment and are relatively easy to collect, but also do not target congestion explicitly. Existing fuel taxes, while not directly used to finance road infrastructure in Canada, are not adjusted for differences in time of use or fuel efficiency, and therefore are not proportional to the ultimate demand for road space (Litman, 2015a). Essentially, road user fees are too low (usually zero) and do not reflect the public costs of providing the infrastructure. As a result, drivers do not think about each kilometre driven, because the cost is so low, and this results in overcrowded roads and sprawling communities.

Without congestion pricing, other policies will not solve the congestion problem

Governments often respond to road congestion by expanding infrastructure. Yet in the long run, new infrastructure generally does not reduce traffic congestion. There are certainly benefits to having new and better roads, such as allowing more people to travel, but costs increase as well. An increase in road capacity usually reduces congestion for a short time, but a "latent demand" for road space then emerges and the roads soon become congested again (Small & Verhoef, 2007).

Similarly, on its own, more public transit may not reduce traffic congestion in the long run because it does not solve the key incentive problem. If additional transit capacity causes more drivers to switch to public transit and frees up road space, the corresponding decrease in traffic can make the roads more appealing to drivers and thereby induce more demand (Duranton & Turner, 2011). Other measures, such as ride sharing and high-occupancy vehicle (HOV) lanes, are possible complements to other more comprehensive pricing measures that can help to reduce driving and congestion (U.S. Department of Transportation, 2008a). Yet, *on their own*, even these measures can induce more driving by increasing road capacity.

In general, expanding public transit and road infrastructure increases the overall capacity of the transportation system, responds to population growth, and is beneficial because it increases the system's total throughput. In the long term, however, these improvements attract more travellers and a return of the congestion problem. Even though the total capacity has increased, the long-run level of congestion is rarely affected.

Some cities have addressed traffic congestion and associated air-pollution problems using *road space rationing*. This approach can reduce congestion by restricting the days or times that given vehicles can be used, based on licence plate. Such systems exist in São Paulo, Mexico City, and other cities in South and Central America on a permanent basis; cities such as London and Beijing have implemented similar systems during special events (Litman, 2015c). With little flexibility, however, rationing approaches of this kind can be quite costly. Driving on a given day, for example, may be very valuable to a given firm or individual, even though other drivers have low-cost alternatives such as public transit. They can also lead to perverse outcomes. Mexico City's road-rationing program, for example, may have worsened air pollution, with the public purchasing additional vehicles to have one available every day, and potentially increasing the overall number of vehicles on the road (Goddard, 1997; Davis, 2008).

Reducing traffic congestion significantly and in a sustained manner requires a different kind of policy. A complete solution requires ecofiscal policies to adjust prices as a means of correcting the market incentives associated with driving.

2.3 ECOFISCAL POLICIES DIRECTLY ADDRESS THE SOURCE OF CONGESTION PROBLEMS

Congestion pricing is just such an ecofiscal policy. Putting a price on traffic congestion can reduce traffic, improve the transport of people and goods, increase incomes and productivity, and enhance the liveability of our cities.

Congestion pricing delivers economic benefits

Congestion pricing can generate economic benefits in three main ways (Button, 2010). First, it can use market forces to allocate available road capacity. When many drivers choose to drive at the same time and on the same route, the resulting traffic increases costs for all of them. Congestion pricing, however, can shift the timing and distribution of traffic and thus reduce these costs (Small & Verhoef, 2007). Different drivers, whether individuals or commercial-goods transporters, respond differently to changes in the price of road use, depending on their circumstance and how policy is applied. They might take alternative routes, use other modes of transport, forgo unnecessary trips, or shift the timing of their travel. Those who can change their behaviour at low cost do so. Those who choose not to alter their behaviour will continue to use the road but pay for the privilege—yet their fee is offset by the reductions in the costs associated with congestion (Button, 2010).

Second, congestion pricing can help indicate where new transportation infrastructure is most needed. As discussed above, free access to roads essentially subsidizes driving. The existence of congestion is therefore currently not an accurate indicator that more road capacity is required; building new infrastructure may simply make driving more appealing. But when drivers pay the full costs of driving under a well-designed ecofiscal policy and adjust their behaviour in response, governments can better determine where additional infrastructure is needed. In particular, congestion pricing can help reveal which new infrastructure will have the greatest value, and what is needed for accessibility and economic prosperity.

Third, congestion pricing can raise revenues available for generating further economic benefits. The primary purpose of congestion pricing is to reduce traffic congestion, but it also generates revenues that could be used to fund road infrastructure, to improve transit, or to reduce existing taxes. Such revenue uses can also help garner support for the policy from a variety of interest groups (Small, 1992). It is also possible to adjust the distribution of the policy's costs and benefits across socio-economic groups, thus improving overall fairness (Eliasson & Mattsson, 2006).

Now is the time for congestion pricing

Traffic congestion is not a new problem, nor is congestion pricing a wholly new solution.

As Canadian cities continue to grow, traffic congestion has emerged as an important and worsening problem. For example, the population of the Greater Toronto Area is expected to increase by

Box 2: Do Canadian Cities Have the Power to Implement Congestion Pricing?

The principal source of local government revenue in Canada is property taxes.

They make up approximately 50% of municipal government revenues, whereas user fees of various kinds contribute roughly 22% (Federation of Canadian Municipalities, 2012). In Canada, provincial legislation generally sets guidelines for how municipalities can collect property taxes, and there is typically variation among municipalities in revenue-collection structures (Kitchen & Slack, 2014).

Canadian municipalities do not generally have the authority to implement congestion pricing on their own (Transport Canada, 2005). According to a review of municipal revenue tools by the British Columbia Ministry of Community, Sport, and Cultural Development (Government of British Columbia, 2012), Metro Vancouver and the City of Toronto are the only two cities with the explicit authority over road tolling. The transit authority in Metro Vancouver, TransLink, has the power to implement tolls to pay for specific infrastructure; however, its tolling capacity must work within the confines of the provincial policy on tolling, which limits it to new projects with a free alternative route (Deloitte, 2010). By contrast, the City of Toronto has the authority to directly implement congestion pricing through the City of Toronto Act, although the city has yet to move forward with its application. No other municipality in Ontario has this authority.

A relatively unexplored way to implement congestion pricing at the municipal level is by levying user fees. Although no municipality has attempted to implement congestion pricing this way, Althaus et al. (2011) argue that if a policy's primary intention is to reduce congestion and influence travel behaviour, municipalities can implement such a policy on municipally owned roads. Furthermore, the federal User Fees Act (2004, c. 6) states that there must be a "direct benefit or advantage to the person paying the fee" and that revenue collected should go toward the purpose of the user fee (i.e., transportation).

The 1998 Eurig decision by the Supreme Court of Canada (S.C.R. 565) provides insight on how the fee and the associated costs are related. Until the Eurig case, governments were required to ensure that fees corresponded precisely to the cost of providing the relevant service. In the case of congestion pricing, this would mean that the toll could not exceed the capital and operating costs of the infrastructure. But the Eurig decision established that the fee must only have a "reasonable relationship" with the costs of the service (Office of the Auditor General of Ontario, 2009). This might allow municipalities to charge an amount that includes capital and operating costs, in addition to some of the wider costs of traffic congestion.

With federal legislation applying to municipalities' authority for levying user fees, and with municipalities also existing as "creatures of the province," there is some uncertainty over where legal authority truly lies. This uncertainty is heightened by the fact that provincially and federally owned roads are connected with each other, and also with municipally owned roads. Despite this uncertainty, one thing seems clear: implementing broader congestion pricing by Canadian cities will require coordination with all levels of government, and may require additional enabling legislation (Althaus & Tedds, 2014).

roughly 100,000 people annually for the next many years (Ontario Ministry of Finance, 2015). Transportation capacity and demand-management strategies lag behind urban growth, which contributes to rising congestion. In Metro Vancouver, under current strategies and patterns, annual congestion costs could nearly triple by 2045 (HDR Inc., 2015).

Congestion pricing is increasingly being recognized as a critical solution to these challenges, with a large body of research showing its benefits (e.g., Vickrey, 1963; Lindsey, 2006). Internationally, cities such as Stockholm, London, Minneapolis, Milan, and San Diego are responding by implementing congestion pricing, and national and subnational governments, such as Germany, Slovakia, Austria, and Oregon, have implemented direct charges for road use. Here in Canada, several public documents reflect rising concerns about traffic congestion and express support for exploring congestion pricing opportunities (e.g., Smeed, 1964; Transport Canada, 2001; City of Vancouver, 2012). Further, an array of government, transit agency, and independent research demonstrates broad support for congestion pricing.[3]

The remaining challenge, however, is *implementation*: congestion pricing is not yet widespread due to a variety of barriers, including public and political opposition (Althaus et al., 2011). We return to these issues in later sections. Box 2 examines whether Canadian cities have the jurisdictional authority to implement congestion pricing policies.

[3] For example: The Royal Commission on National Passenger Transportation (1992); Transport Canada (2001); Transport Canada (2014)—the latest Canada Transportation Act Review process.

3 THE CONGESTION PRICING TOOL KIT: FIVE CASE STUDIES

Different policy tools can price traffic congestion in different ways. Most tools fall into five broad categories: (1) single-entity pricing; (2) high-occupancy toll (HOT) lanes; (3) zone-based pricing; (4) distance-travelled pricing; (5) parking pricing. This section examines these instruments and explores five case studies, one for each policy type. These case studies illustrate how congestion pricing policies can work in practice and generate insights that help inform the design of effective policy.

3.1 SINGLE-ENTITY PRICING (CASE STUDY #1: HIGHWAY 407 IN ONTARIO)

Single-entity pricing instruments are the most common form of congestion pricing. Such an instrument charges a fee to use a specific piece of infrastructure. It usually takes the form of a toll for a road, tunnel, or bridge (Litman, 2015c). Current examples of full road tolls in Canada include Ontario's Highway 407, bridges on Quebec Autoroutes 25 and 30, two bridge crossings over the Halifax Harbour, and Metro Vancouver's Port Mann and Golden Ears bridges.

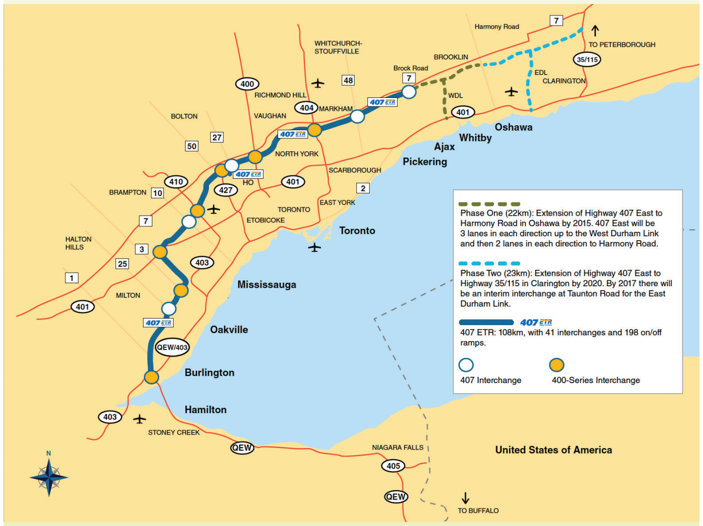
Overview of Highway 407 Express Toll Route

In response to increasing congestion on Highway 401 in the Greater Toronto Area, and despite multiple expansion efforts, the Ontario government opted to build Highway 407 in 1986 (Sewell, 2010). Due to financial constraints, the provincial government built the 407 ETR (Express Toll Route) as a tolled facility to finance its construction and then sold the highway as a concession soon after its opening. Tolling began in October 1997, making the 407 ETR the first open-access, all-electronic toll highway in the world.

The private operator of Highway 407 has the authority to set tolls and collect toll revenues, and is responsible for the operation, maintenance, and expansion of the highway. Tolls are paid through transponders placed in customers' vehicles or through cameras and licence plate recognition. Figure 1 shows the 407 ETR, other major highways in the region, and the two scheduled Highway 407 extensions (the ownership of which will reside with the provincial government). Highways 7 and 401, which run parallel to the 407 ETR, have remained un-tolled alternative routes.

In response to high demand, the structure of the toll has evolved to include variable pricing. The per-kilometre charge for light vehicles during weekdays, for example, varies from 19.74¢/km during off-peak hours to 34.73¢/km during afternoon peak hours (407 International Inc., 2015a). In addition to the per-kilometre tolls, drivers leasing transponders are charged $3.55 per month plus $0.90 per trip. Drivers relying on the highway's licence plate recognition technology are charged $3.55 per month plus $4.90 per

Figure 1: 407 ETR and Major Highways in the Greater Toronto and Hamilton Area



Source: 407 International Inc. (2014).

trip. The higher price of using the licence plate technology acts as an incentive for regular users to purchase a transponder.

Lessons learned from Ontario

Four key lessons emerge from the experience with Ontario's 407 ETR.

1. Congestion pricing can be effective

A recent study estimates that, on average, commuters using the 407 ETR save 18% to 36% of their total commute time relative to using a free option (Gill & Knowles, 2013). In terms of total time saved, this translates into approximately 20 minutes per day (including both morning and afternoon commuters), or 26 minutes per day if factoring in planning time.

Variable time-of-day pricing has played a key role in keeping the 407 ETR congestion-free, in contrast to the heavily congested Highway 401 and Queen Elizabeth Way (QEW). From 2008 to 2013, travel times on the 401 during peak traffic times were 50% to 200% above off-peak times (Gill & Knowles, 2013). Customers using the 407 ETR, on the other hand, have rarely experienced any congestion on either eastbound or westbound routes, even during peak traffic times, despite an overall increase in usage of 8% since 2008 (407 International Inc., 2015b).

2. Aligning benefits with users increases public acceptability

Fees on the 407 ETR have funded the highway's construction and operation. As a result, users are the direct beneficiaries of the revenue generated from the tolls. Despite some initial opposition, there is growing acceptance of both the toll and the operator, which justifies the toll as necessary for providing a congestion-free experience for its customers. The greatest evidence of the public's acceptance is the sheer volume of daily traffic on the 407 ETR, along with the residential and commercial development along the corridor: drivers are choosing the 407 ETR to avoid congestion. Job hubs close to the 407, for example, have generally grown at a faster pace than others in the Greater Toronto Area (GTA) (Gill & Knowles, 2013).

3. Private implementation has some disadvantages

Although the original intent of the 407 ETR was revenue generation to fund its construction and operation, congestion management has become an essential issue in the highway's ongoing operations (Mylvaganam & Borins, 2004). But because the highway is privately run, the Ontario government has little influence in determining the toll structure. Reducing tolls on the 407 ETR, for example, might ease combined levels of congestion on alternative routes, but it is out of the provincial government's control. With congestion in the GTA reaching unprecedented levels, integrating the objectives and management of Highway 407 into a regional plan is an ongoing challenge.

4. Technology is no longer a significant barrier to implementation

Billing errors and "unbillable" trips (due to transponder errors, camera failures, and software glitches) have declined substantially over time. Similar technology is being employed elsewhere, including within Canada, such as at the Port Mann Bridge in Metro Vancouver. As technology continues to improve, this is likely to be an even smaller barrier to future congestion pricing policies.

3.2 HIGH-OCCUPANCY TOLL (HOT) LANES (CASE STUDY #2: MINNESOTA MnPASS SYSTEM)

High-occupancy toll (HOT) lanes impose a price on a portion of a road. This policy typically involves converting high-occupancy vehicle (HOV) lanes to HOT lanes or building new HOT-lane capacity, not reducing existing road capacity. HOV lanes are restricted to buses and private passenger vehicles with multiple occupants. HOT lanes give single-occupancy vehicles access to these separate, faster, and more reliable lanes, usually with prices that vary dynamically in response to demand or by time of day. The United States now has more than 470 km of HOT lanes, with 262 km under construction (Urban Land Institute, 2013). Canadian cities have yet to introduce HOT lanes, although Ontario has recently expressed its intent to implement them in the GTA.

All drivers on highways with HOT lanes can benefit. HOT-lane users receive a direct benefit from shorter and more reliable commute times, while other road users benefit from less congestion in the general-purpose lanes. And unlike more comprehensive congestion pricing systems, road users have the choice to pay and use the faster, more reliable HOT lanes or stay in the free, more congested lanes. This flexibility is a key virtue of the HOT-lane approach to reducing traffic congestion.

Overview of the Minnesota MnPASS HOT lanes

The Minnesota Department of Transportation (Mn/DOT) introduced one of the first dynamically priced HOT lanes in 2005, known as the MnPASS system. It converted underused, two-person-minimum HOV lanes to HOT lanes with the objectives of reducing congestion while increasing road capacity, reducing the need for new infrastructure, and improving the uptake of carpooling and public transit (Government of Minnesota, 2004). Buses, carpools with two or more people (referred to as “2+”), and motorcycles access the HOT lanes for free, while single-occupancy vehicles must pay an electronic fee of US$0.25 to US$8.00, depending on traffic levels (Buckeye, 2012). The tolls change every three minutes according to the HOT lanes’ throughput and speed, and are displayed on electronic signs posted along the route (Government of Minnesota, 2013). MnPASS lanes are usually priced only during peak hours.

The MnPASS system uses electronic sensors to detect vehicles and collect tolls through the network, which is made up of lanes separated from regular traffic by painted double white lines or concrete barriers, including a reversible segment that changes direction to respond to vehicle flow at different times of day. More than 25,000 drivers lease transponders that deduct tolls from their prepaid accounts (University of Minnesota, 2014). Transponders are only activated when placed on a clip on the windshield, allowing drivers to turn off the transponder if they have other passengers in the vehicle, thus qualifying for free use of the lanes (Buckeye, 2012).

Lessons learned from Minnesota

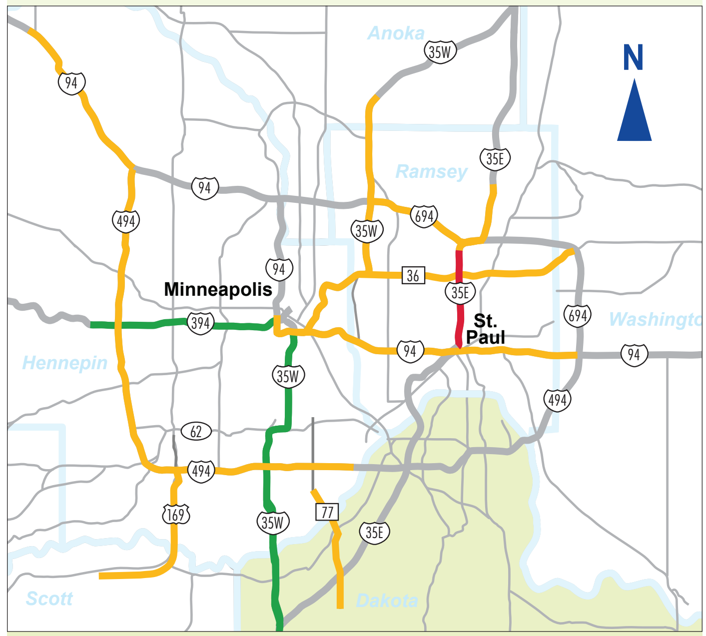
Four key lessons emerge from Minnesota’s experience with HOT lanes.

1. HOT lanes can be effective in reducing congestion

The MnPASS system has been effective at reducing congestion, optimizing traffic flows, and increasing transit ridership along the tolled routes (Government of Minnesota, 2013). In addition to maintaining free-flow speeds of at least 50 mph in the tolled lanes, the MnPASS system increased traffic speeds by 6% in the general-purpose lanes. Moreover, total corridor throughput during peak hours increased by 5% on I-394, while traffic throughput on other non-MnPASS corridors decreased slightly (Cambridge Systematics, 2006). The total number of trips using MnPASS HOT lanes nearly doubled between 2009 and 2013 (Government of Minnesota, 2013).

As a sign of its success, the Mn/DOT has since expanded the system to include the I-35W corridor, with plans for a much wider expansion (Government of Minnesota, 2015). Figure 2 provides an overview of the proposed expansion.

Figure 2: Existing and Proposed HOT Lanes in Minnesota



Source: Government of Minnesota (2015).

Existing MnPASS
35E MnPASS Construction 2013-2015
Future Managed Lane or MnPASS System

2. Toll revenues are modest, but can cover capital and operating costs

The primary objective of the MnPASS system is to reduce congestion and optimize road use. As such, tolls are priced to effectively manage traffic and not to generate revenue; compared with other road-pricing systems, the MnPASS tolls are relatively low (Buckeye, 2012). The MnPASS system generated $600,000 in net revenues in 2012 (Government of Minnesota, 2013) and, if future ridership does not fall, it will continue to generate enough revenues to cover operating and enforcement costs. Half of surplus revenues are devoted to capital investments for the corridor, while the other half is devoted to improving public transit (Cambridge Systematics, 2006).

3. Successful implementation depended on a number of city-specific factors

One of the primary factors for success is the extensive network of HOV lanes in place prior to introducing the HOT lanes. As a result, construction costs were lower, because building new lanes was not required. Preserving the same number of general-purpose lanes also improved public attitudes toward the program (Buckeye, 2012).

The practicality of HOT lanes depends on several other city-specific factors, such as plans for additional HOV lanes, population density, congestion levels, employment hubs, other transportation management tools in use, traffic safety, enforcement capacity, HOV utilization, transit ridership, number of people per vehicle, and public perception (Eisele et al., 2006; Transport Canada, 2010). Each of these factors played a role in the success of the MnPASS system and requires close consideration in the Canadian context.

4. Multiple levels of government can play a role in implementation

The Mn/DOT acted as the primary decision-making body for designing and implementing HOT lanes. This helped in developing a consistent long-term regional plan for the city. In addition, the DOT received financial support from the federal government, with a grant of $133 million to help expand the MnPASS system to the I-35W corridor (Munnich, 2008).

3.3 ZONE-BASED PRICING (CASE STUDY #3: STOCKHOLM CONGESTION CHARGE)

Zone-based pricing systems charge a fee to use designated roads within a given geographical area. Terminology varies, with zone-based policies often referred to as c*ordon pricing* or *area pricing*. Pricing can apply to any movement into, out of, or within a defined perimeter of a zone (Samdahl et al., 2013). In some systems, drivers pay each time they cross a perimeter, while in others, drivers pay once daily. No zone-based systems currently exist in Canada; they have been implemented in cities such as Stockholm, London, Milan, Singapore, and several in Norway. Some U.S. cities have also experimented with zone-based approaches (Move NY, 2015).

Overview of Stockholm's congestion charge

The primary objective of Stockholm's 2006 seven-month trial for congestion pricing was to make travel in the city's centre more efficient by reducing traffic congestion. The policy established a cordon around the city's central core that charges vehicles both entering and leaving the area using transponders or cameras. The price for passage through the cordon varies between $1.50 and $3.00 (Canadian 2015 dollars) depending on the time of day, with the highest charges occurring during peak hours (Hamilton, 2010). Users are required to pay the charge within five days of passage, paid either automatically through direct debit from their bank, manually through a payment from their bank, or in cash at local convenience stores. After a referendum in 2006, the policy was introduced permanently.

Lessons learned from Stockholm

Five main lessons emerge from Stockholm's zone-based pricing policy.

1. The policy was effective for reducing both congestion and air pollution

The Stockholm policy successfully achieved its primary goal of reducing traffic congestion. After 15 years of relatively stable traffic levels (with roads at or near their capacity), traffic levels immediately decreased following implementation. While the goal of the Stockholm trial was to decrease the number of vehicles crossing the cordon by 10% to 15%, the actual average reductions observed during the trial period were 20% to 30% (Hugosson & Eliasson, 2006).

In terms of public transit, overall trips increased by 4% to 5% (Eliasson, 2014). Parallel investment in public transit—increasing the supply of a key alternative to driving—facilitated the increase, but the tolls played a key role in incentivizing drivers to substitute toward public transit (Hugosson & Eliasson, 2006). Similarly, the congestion charge resulted in a 4% to 10% reduction in GHG emissions and a 7% to 9% reduction in air pollutants (Herczeg, 2011).

2. The policy delivered net benefits

The policy delivered clear net benefits in the form of shorter and more reliable travel times, cleaner air, fewer GHG emissions, and reduced accident risk. With an estimated start-up cost for the program of $340 million (in 2015 Canadian dollars), a cost–benefit analysis of the policy found that it would generate net benefits for society after roughly 3.5 years, including the direct financial charges to drivers (Eliasson, 2009).

A lingering criticism of Stockholm's congestion charge is the relatively modest generation of net revenues. In 2008, $65 million was budgeted for operating costs, with forecasted revenue for the year of $129 million (Eliasson, 2009). Compared with congestion charges in other jurisdictions, the operational costs in Stockholm made up a larger percentage of revenues. Proponents of the Stockholm system, however, note that the primary goal of the scheme is to reduce traffic congestion in the city, not to raise new revenues. Moreover, operating costs are expected to decrease in the long run as technology improves.

3. Public acceptability increases after effective implementation

Leading up to Stockholm's seven-month trial, many in the centre-right political opposition party were certain the project would fail. The Automobile Association and Stockholm Chamber of Commerce campaigned against the project through ads, newspaper articles, pamphlets, and a campaign website. In addition, the Swedish Tax Agency warned that the program could lead to children being indebted as parents register vehicles in their children's names to avoid paying charges. The National Collection Agency estimated that 6,000 cases would be transferred onto legal collections every day (Hamilton, 2010).

Yet the Stockholm experience suggests that demonstrating genuine benefits to the public is one way of increasing public acceptability. After the trial was completed, a referendum was held asking whether to permanently introduce congestion pricing in Stockholm. To the surprise of many observers, 53% of the city's residents voted in favour of instituting the program permanently, despite low and unfavourable levels of support prior to the trial (Schuitema et al., 2010). Public support for the policy was lowest just before the trial began, at 34%, but increased steadily over time, reaching 65% by 2007 and over 70% by 2013 (Eliasson, 2014).

After the trial was over, respondents indicated they realized greater benefits than originally expected, including more parking availability, less congestion, and reduced pollution. Respondents also found that adaptation and increased travel costs were less burdensome than anticipated. Several media outlets also changed their views about the policy after seeing its effectiveness at reducing congestion.

4. Revenue use can also affect public acceptability

Revenue generation, though not the main goal of the congestion charge in Stockholm, played an important role in the success of the trial policy. Net revenues were transparently earmarked as part of a comprehensive transport investment package, including both road and public transit improvements. This made the congestion charge more palatable, and also helped address key equity issues: improvements to public transit financed by the policy were seen to disproportionately benefit lower-income groups (Börjesson et al., 2012).

The net revenues were also integrated into a national investment plan, giving local and regional governments significant influence on how to use the revenues. Each of these design features meshed with the unique geographic and socio-economic landscape of Stockholm, improving the overall acceptability of the congestion charge during and after the 2006 trial.

5. Effective communication with the public increases acceptability

In an article published a few years after the trial (Eliasson & Jonsson, 2011), low car dependence and good public transit were found to be associated with higher levels of acceptability of the congestion charges in Stockholm. The two most important factors identified in the analysis were respondents' beliefs about the effectiveness of the congestion charge and general environmental attitudes. The authors went on to recommend that congestion charges may be most successfully framed as "environmental charges" in order to win public acceptance.

3.4 DISTANCE-TRAVELLED CHARGES (CASE STUDY #4: OREGON'S PILOT PROJECTS)

Distance-travelled charges are typically levied on all roads in a given region and can vary depending on distance, time, direction, and location (Samdahl et al., 2013). (The previous instrument category involves charging in a given area, but not based on the distance driven.) While the 407 ETR toll depends on distance travelled, Canada currently has no *region-wide* distance-based charges. Several countries in Europe have distance-based charges for heavy-duty trucks, depending on vehicle emissions and the number of axles (Toll Collect GmbH, 2015; European Commission, 2015).

Overview of Oregon's distance-travelled pilot programs

In response to declining fuel-tax revenues and a widening infrastructure funding gap, Oregon's Road User Fee Task Force recommended distance-based pricing, implemented through a series of pilot projects (Oregon Department of Transportation, 2013). The first 10-month pilot project in 2006-07 tracked mileage from wireless GPS devices to study the feasibility of using distance-based fees to replace the gas tax and, as a secondary goal, its adaptability to reduce traffic congestion.

Based on feedback from the first pilot program, and the emergence of smartphone technology, the second pilot project let participants choose between basic plans, which reported only mileage, and advanced plans, which reported both mileage and location. Participants were billed monthly at a rate of 1.56 cents per mile and received a rebate for fuel tax paid. Depending on the type of plan selected, they received an electronic invoice paid online or a paper invoice paid by cheque. Overall, the revenue generated under the pilot program was 28% greater than the fuel taxes that would otherwise have been collected (Oregon Department of Transportation, 2013).

Oregon then designed a third pilot project for up to 5,000 cars and light-duty commercial vehicles with a price of 1.5 cents per mile, which started in July 2015 and is referred to as "OReGO" (Oregon Department of Transportation, 2015). This project is volunteer-based and is intended to serve as a permanent alternative to raise money for roadway infrastructure.

Despite the success of the first pilot project in showcasing the benefits of distance-travelled pricing for reducing traffic congestion, the task force decided to focus strictly on the revenue-generation objective for the second and third pilots. The task force proposed that congestion pricing should be designed and implemented at the local level, not at the state level.

Lessons learned from Oregon

Although the objective of the distance-based program in Oregon was ultimately to generate revenue and not reduce traffic congestion, four main lessons emerge from the state's pilot projects.

1. Distance-travelled charges can reduce traffic congestion

The original pilot in 2006 suggests that distance-based pricing can be used to effectively reduce congestion. By increasing the distance-based fees during peak periods, drivers during rush hour reduced their peak-period mileage by 22% (Oregon Department of Transportation, 2007). Contrary to original expectations, drivers in the peak-pricing group also drove 14% less during off-peak periods, suggesting that some participants did not substitute driving during peak hours for driving during off-peak times. Another important finding is that households in denser and mixed-use neighbourhoods were more likely to reduce their driving mileage than those living in other, less dense neighbourhoods (Guo et al., 2011).

2. If reducing congestion is a primary goal, structural change to the program is required

Oregon's second pilot project provided the option to report only mileage, without time or location information included. To be used for congestion management, a usage-based charge program would likely need to include either time or location (ideally both) so as to target those trips creating the most congestion. In addition, the system would require drivers to participate fully to be effective. A voluntary program that increased user charges by time of day and on congested links would likely see users opt out (or not opt in) to avoid the higher fees. The use of such a charge for reducing congestion would then require some level of coercion.

3. Program costs as a share of total revenues decline with increased participation

Compared with the gas tax, which costs roughly 0.5% of total revenues to administer, the distance-based program is considerably more expensive owing to high start-up costs (Oregon Department of Transportation, 2013). Estimates from the second pilot study indicate that the operating costs for a program involving 10,000 vehicles would consume approximately 20% to 30% of revenues. But because much of the program costs can be administered electronically, the marginal cost of each additional user is extremely small. Because of these economies of scale, the Oregon Department of Transportation (2013) estimates that the total program costs will drop below 5% of total revenues for a system with one million users.

4. Privacy and customer choice are an evolving concern for acceptability

The first pilot project experienced strong opposition related to drivers' concerns about a program that required them to share their location information with the government (Oregon Department of Transportation, 2013). To address these concerns, the second pilot project included an option that reported mileage without GPS data. The government also conducted extensive outreach to educate the public on the positive aspects of the program.

More recent experience with smartphones and GPS devices that provide real-time traffic conditions suggests that the public is mostly willing to accept some loss of privacy if they are provided with an immediate benefit and choice. For the purpose of implementing distance-based pricing, users provided with some corresponding direct benefits may be similarly willing to participate.

3.5 PARKING PRICING (CASE STUDY #5: SAN FRANCISCO AND CALGARY PARKING PRICING)

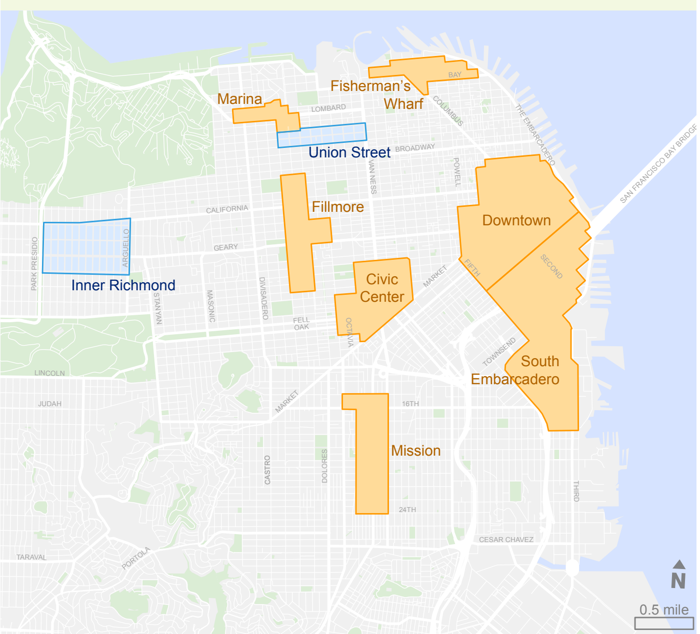
Parking prices can also be designed to reduce traffic congestion by creating incentives for shifting transportation choices across time, mode, or location (Samdahl et al., 2013). While most cities use flat-rate structures for parking meters, a variable pricing structure can reduce congestion and improve parking availability. Calgary has recently implemented demand-based parking pricing, and San Francisco recently completed a pilot project, SFpark.

Overview of San Francisco's parking pricing pilot project

In an effort to improve parking access and reduce traffic congestion, San Francisco implemented a two-year pilot project in 2011. To optimize parking access and reduce the total time spent circling while searching for spaces, the project increased prices on parking spots with high demand and reduced prices on spots with low demand in several pilot areas. The project aimed to capture benefits from reduced congestion, such as a faster-operating public transit system, cleaner air, safer conditions for pedestrians and cyclists, and increased economic vitality. Funding for the project came primarily from a US$19.8 million grant from the U.S. Department of Transportation, with the remainder covered by the San Francisco Municipal Transportation Agency (SFMTA, 2011). Following analysis after the pilot project ended in 2013, the first-of-its-kind program was deemed a success. The city recently finished upgrading all of its parking meters to the "smart meters" that enable demand-based price changes, and plans to expand the pricing program throughout San Francisco (Bialick, 2015).

As shown in Figure 3, the project included eight pilot areas and three control areas, covering 7,000 metered spaces (25% of the total available) and 12,250 off-street spaces (75% of the total available) (SFMTA, 2014). Rates varied by each city block and were adjusted monthly in an attempt to achieve the target occupancy rate of 60% to 80% of all parking spots. Rates were capped at $6/hour, with an $18/hour cap during special events.

Figure 3: San Francisco's Pilot Project Zones



Source: SFMTA (2014).

The project used wireless in-ground sensors to detect when vehicles occupied specific parking spaces, connected to a city-wide communications network. Customers had access to real-time information on parking availability via a mobile application, through a website, or via text message. New message signs indicated to drivers entering downtown which parking garages have real-time availability (SFMTA, 2014). Roadway sensors monitored the impacts on traffic.

Lessons learned from San Francisco

Five main lessons emerge from San Francisco's experience.

1. Parking and congestion objectives can be complementary

The SFpark program effectively optimized parking space. The amount of time the target occupancy rate was achieved increased by 31% in the trial areas, compared with 6% in the control areas (SFMTA, 2014). Moreover, the amount of time that city blocks were too full for drivers to find a parking space (corresponding to 90% to 100% occupancy) decreased by 16% in pilot areas and increased by 51% in control areas (SFMTA, 2014). In short, scarce parking spaces were more efficiently allocated as a result of the policy.

The pilot project also achieved other objectives. In areas where parking availability improved (in both pilot and control areas), traffic volumes went down by approximately 8%. In areas where parking availability worsened, traffic volumes increased by 5% (SFMTA, 2014). Circling for parking—a major contributor to downtown traffic—was estimated to have declined by 50% (Millard-Ball et al., 2014). Vehicle miles travelled also decreased by 30% in the pilot areas compared with a 6% decrease in the control areas (SFMTA, 2014).

The SFMTA also claims that peak-period traffic congestion decreased by providing people a financial incentive to travel during off-peak periods. Parking availability on the street improved by 22% during peak periods, and off-peak parking garage exits increased by 15% (SFMTA, 2014). Both statistics suggest that the SFpark program helped to reduce peak congestion.

While SFMTA's own evaluation of the SFpark program found it successful, an independent evaluation concludes that the target occupancy level did not necessarily correspond with increased levels of availability. In other words, some city blocks achieved the average occupancy target of 60% to 80%, yet many were still too full (90% to 100%) for drivers to find parking in high-demand areas. The study found that the price in high-demand areas would need to be higher than the imposed cap of $6/hour to sufficiently increase availability rates. Moreover, price levels in pilot areas did not seem to reduce parking duration, or increase vehicle turnover and carpooling (Chatman & Manville, 2014).

2. Trade-offs exist between fairness and effectiveness

While certain high-demand areas experienced price increases, the overall average price for parking in San Francisco actually declined using dynamic pricing. This decline was partially caused by the $6/hour cap on prices. Independent research suggests that the SFpark program would be more effective at increasing the availability of parking if prices were allowed to float freely according to fluctuations in demand (Chatman & Manville, 2014). However, this raises important equity issues on the affordability of parking. Pricing structures must therefore balance program effectiveness with its overall affordability.

3. Public acceptability remains a challenge, even after successful implementation

Gaining public support for the SFpark program has been challenging, as many residents remained skeptical even after its implementation. This was primarily due to the meter expansion into residential neighbourhoods and paid metering on Sundays, dampening plans for expansions of the program in the shorter term (Manville, 2014).

4. Cooperation between different levels of government is valuable

The SFMTA benefited through the funding partnership with the U.S. Department of Transportation, while the DOT benefited from implementing a trial program in a major city that others can emulate. Importantly, parking policy in the United States is almost exclusively within the purview of municipalities, allowing city governments to take direct action.

5. Simplifying technology can make policy more practical

The SFMTA abandoned using specifically installed sensors after the pilot program; instead, the expanded program takes readings directly from (paid) smart meters as to whether a spot is available. Installing sensors was an additional expense and hassle that could be avoided in future programs by collecting information from meters or other existing technologies. To complement the smart meters, using mobile apps to communicate information to drivers proved to be a simple and cost-effective way to provide drivers with information.

A parallel approach in Calgary

Based on the San Francisco model, Calgary implemented a dynamic pricing approach to parking, called ParkPlus, in 2013. Similar to SFpark, rates vary across 27 discrete areas in the city to encourage more parking in underutilized areas. While price adjustments in San Francisco are made monthly, prices in Calgary are adjusted only annually, and aim to achieve a target occupancy rate of 50% to 80% (Calgary Parking Authority, 2015). The City of Calgary recognizes that more frequent price changes would be more responsive to demand and thus more effective in allocating the scarce parking spots. But it also aims to provide stable prices and avoid large seasonal fluctuations (City of Calgary, 2015a).

In contrast to the significant opposition to the program in San Francisco, the ParkPlus program in Calgary has kept a low profile. This is partly due to the smart meters already being in place when the shift to dynamic pricing was made, and also the minor change in parking price.

While still too early to determine its overall effectiveness, using demand-responsive pricing to manage parking demand is anticipated to help achieve target occupancy levels. This will reduce circling for parking spots in high-demand areas and improve overall traffic congestion.

3.6 SUMMARY

Each of these case studies carries important lessons relevant to the design and implementation of congestion pricing policies. Ontario's 407 ETR illustrates that congestion pricing can work in Canada, and highlights the possible role of the private sector for program administration. Minnesota's experience demonstrates that converting HOV lanes into HOT lanes can offer drivers a congestion-free commute while still preserving a free alternative. Stockholm's congestion charge shows clearly that public acceptance can increase once people experience the benefits. Oregon's pilot projects show that technology is available to enable distance-based charging—whether the primary objective is increased revenues or reduced congestion. Finally, San Francisco's experiment with dynamic, demand-responsive parking pricing is an innovative example highlighting the role that parking price and availability plays in traffic congestion. Calgary's similar parking program demonstrates that Canadian cities can unilaterally use parking prices as part of a wider congestion-reduction strategy.

4 DESIGNING CONGESTION PRICING POLICY: EVALUATION OF TRADE-OFFS

As the case studies suggest, different design choices for congestion pricing policies have both advantages and disadvantages. This section explores these trade-offs more fully, and the next section considers how local context in specific cities might affect design choices.

4.1 EVALUATION FRAMEWORK

Our framework compares three policy design choices along each of four evaluation criteria.

Policy design choices

We consider three design choices for congestion pricing policy. The policy tools considered in Section 3 map across these choices in different ways.

- **Coverage** refers to the scope of the congestion price. Different policy tools apply a congestion price more or less broadly across drivers and trips. The policies considered in the five case studies in Section 3 vary in their coverage, from the narrower San Francisco parking and Toronto and Minnesota highway examples to the broader Stockholm cordon-based charge and Oregon's distance-travelled charge.

- **Pricing** refers to the variability of rates across time and space. Tolls for a bridge, road, or zone might be the same at all times or could be higher during peak traffic times, as in Stockholm. Distance-travelled pricing could vary depending on current congestion conditions, with higher prices when and where more congestion exists, as in Minnesota.

- **Revenue use** refers to how funds generated from congestion pricing are used. Financing reductions in other taxes, investing in infrastructure or public transit, and making direct transfers to households are three specific examples. Each has different implications for the effectiveness, net benefits, fairness, and practicality of the policy.

Evaluation criteria

For each design choice, we consider four evaluation criteria:

- **Effectiveness** is the extent to which a policy achieves its stated objective. Congestion pricing policies might have different—though interrelated—objectives. We focus here on the goal of reducing congestion, paralleling Althaus et al. (2011), who argue that keeping this primary objective at the forefront during design and implementation can provide coherence to pricing systems. We examine implications for revenue generation as a secondary objective where appropriate.

- **Net benefits** refers to the extent to which a policy achieves benefits (from lower congestion, more efficient road use, and smart revenue use) that exceed the direct costs for drivers and the costs of administering the policy.

- **Fairness** considers two kinds of equity. In the context of congestion pricing, *vertical equity* is the extent to which the policy avoids disproportionately affecting lower-income households. *Horizontal equity* is the extent to which drivers or groups of drivers (i.e., passenger as opposed to commercial) are treated equally and receive benefits commensurate with the fees they pay (Litman, 2002).

- **Practicality** is the extent to which a policy can actually be implemented. It considers technical barriers, legal and jurisdictional constraints, and public acceptability.

We now examine the trade-offs among the three design choices according to these evaluation criteria.

4.2 COVERAGE

A key difference across the various congestion pricing instruments is the breadth of policy—that is, the scope of the congestion price. A toll that applies only to a single road or bridge is relatively narrow (and even narrower if it applies only to individual lanes on that road). Parking policies are narrow in a different way, given they affect only the subset of drivers looking to park in a given area, and not those passing through the area toward some other destination, and also because some people have access to private free parking (so may be unaffected by parking pricing policies). Zone-based approaches tend to be broader, applying to driving in specific areas or across given boundaries. Distance-travelled policies can be broadest of all, given they could apply to all eligible drivers in a region based on the distance they travel.

Effectiveness

Broader congestion pricing policy tends to be more effective at reducing traffic congestion, because narrower approaches typically shift the congestion to nearby roads. A toll on a single bridge or road can lead to increased congestion on alternative, unpriced routes (Lindsey & Verhoef, 2001), while broader approaches price travel on a greater number of alternative routes.

In Metro Vancouver, for example, tolls on the new Port Mann Bridge have led to increased congestion on the Pattullo Bridge, an alternative crossing 3 km away. A *National Post* article noted, for example, that there was a 25% increase in the number of heavy trucks using the Pattullo Bridge in the month after tolling began on the Port Mann Bridge (Sinoski, 2013). Residents near the Pattullo Bridge also describe increased congestion in the surrounding area (CBC News, 2014). In contrast, in New York City, many bridges and tunnels entering the five boroughs are tolled, creating a broader price signal across facilities, and contributing to the city's residents' extensive use of public transit.[4]

A city's geography is an essential consideration, however, as it creates both barriers and opportunities for effective policy. Multiple centres of activity could mean that pricing with low coverage may fail to create incentives for all drivers to change their behaviour. Alternatively, if travel to specific destinations—for example, commuters going to work or tourists shopping—is a key factor in a city's traffic problem, parking pricing can be effective, even though it only covers a subset of all trips (Shoup, 1982; Small & Verhoef, 2007). Shoup (2006) estimates that an average of 30% of cars in downtown traffic are circling for parking, and typically take more than eight minutes to find a parking spot.

Net benefits

The two factors underpinning net benefits—the extent to which a policy optimizes road use and the policy's administrative costs—generally work in opposite directions with respect to the breadth of congestion pricing policy. Again, geography affects these trade-offs.

In terms of improving the efficiency of road use, policies that more directly price congestion tend to be more cost-effective (Small & Verhoef, 2007; de Palma et al., 2006). If drivers on routes *without* congestion are priced, costs to transportation are added without a corresponding improvement in travel times. As a result, the net benefits of different instruments depend on the locations of congestion: comprehensive approaches can be more cost-effective for broad congestion problems, and narrower ones for more localized issues (though only if it does not lead to congestion being displaced to alternative routes, as discussed above).

In terms of minimizing administrative costs, however, broader policy tends to be more complex and costly to operate (de Palma & Lindsey, 2011). The costs of roadside infrastructure and vehicle-recognition systems required to enforce and apply a congestion price can be high (Lindsey & Verhoef, 2001). London's congestion charge, for example, generated relatively little net revenue,

[4] New York City is also currently considering a plan to reform its approach to tolling, balancing tolls across a greater number of bridges and key links within Manhattan, charging more where congestion is worse, and potentially incorporating time-of-day pricing (Move NY, 2015).

partly because of these administrative costs, although they have decreased over time (Dix, 2006; Transport for London, 2014). On the other hand, narrow approaches can be relatively easily implemented; underused HOV lanes, for example, can be converted to HOT lanes quite easily (Lindsey, 2007).

Which of these effects dominates depends on local geography. For example, cities with natural cordon areas (such as Halifax or the Island of Montreal) can potentially target pricing policy to congested areas via the limited number of access points to the congestion zone. Customizing breadth of policy to geographic context could thus target congestion zones with relatively low administrative costs.

Specific geographic characteristics can also decrease the efficiency of policy. Santos and Fraser (2006) note that the failed second phase of congestion pricing in London—the "western extension"—failed a cost–benefit analysis. The extension covered an area of London more similar to North American cities, with important arteries running through and no real alternatives, and for this reason the policy generated only slight benefits.

Fairness

Broader congestion pricing tends to increase the horizontal equity of a policy because more drivers and more trips are treated equally. However, broader congestion pricing can reduce vertical equity because congestion fees typically represent a larger share of income for lower-income households (Litman, 2002). Exempting some trips or leaving toll-free options reduces the policy's breadth of coverage (and thus its overall effectiveness), but can improve fairness by providing a lower-cost alternative (Ecola & Light, 2009). Lindsey (2008) notes that exemptions or discounts to those living within a cordon area, as well as to drivers that depend on a tolled route to get home, to frequent users, and to taxis and low-emissions vehicles can increase real and perceived fairness. The use of HOT lanes, the 407 Express Tolled Route in Ontario, the two tolled bridges in Greater Montreal, and the Port Mann and Golden Ears bridges in Metro Vancouver are all examples of pricing that have un-tolled alternatives, thus improving the vertical equity of the policies.

Geography also affects fairness. Ecola and Light (2009) note that the fairness of zone-based congestion pricing depends on the location of different income groups relative to the charging zone. Zone-based pricing, for example, would capture multiple income groups; however, there would be equity concerns from those who commute into the area.

Practicality

The breadth of a congestion pricing policy has mixed implications for its practicality, both legally and in terms of its public acceptability. Once again, local geography affects these trade-offs, but so do local differences in attitudes, culture, and governance structures.

Broader coverage may be harder to implement in light of legal and jurisdictional barriers, particularly in some cities. As noted previously, different levels of government typically own different roads in major Canadian cities. Municipalities in Canada can only administer congestion pricing policies on municipally owned roads (Althaus et al., 2011).

Local policy context also affects practicality. British Columbia's existing tolling policy stipulates that tolls can apply only to new facilities, should generate a return on investment, and that a reasonable toll-free alternative must exist (Government of British Columbia, 2003). While the province has indicated that it is open to revisiting this policy, the policy necessitates provincial involvement in any discussion of broad congestion pricing policy (Nagel, 2013).

Broader policy may also increase public opposition. Narrower policies tend to leave drivers with more choices for routes, and impact fewer people. For example, when London's congestion charge was extended geographically, opposition from businesses in particular led to the removal of the extension within four years. Of those residents consulted, 62% backed its removal (Noordegraaf et al., 2014).

4.3 PRICING

A key aspect of pricing is the extent to which a congestion price varies across space and time. Prices could be higher, for example, at scheduled times when commuter traffic is typically greatest. Prices could also vary dynamically (in real time) in response to changing levels of congestion.

The extent of price variability is a design choice for all kinds of pricing tools. Toll rates, the price of accessing a congestion zone, or even parking prices can remain flat or vary across time, both in a predictable, structured way depending on time of day, or in response to changes in demand. See Box 3 for additional details on the implications of pricing structure for secondary objectives.

Effectiveness

Variable congestion pricing is generally more effective at reducing traffic congestion than are constant prices (de Palma & Lindsey, 2011). Tolls, congestion charges, and distance-based rates that vary over time create incentives to shift the timing of travel to reduce peak congestion periods. Time-varying prices provide incentives to those with schedule flexibility or alternative modes of transport. After Singapore moved from its initial physical tolling policy to the Electronic Road Pricing system in 1998—which had greater time variability in rates—traffic became more dispersed throughout the

Box 3: Pricing Variability and Secondary Objectives

While price variability can make congestion pricing policy more effective at reducing traffic congestion, it may have the opposite impact on secondary objectives such as revenue generation or the reduction of air pollution.

Lindsey (2008) notes that the optimal rate structure for road pricing differs as to whether the policy's objective is congestion reduction or revenue generation. Variable pricing can customize incentives for reducing traffic congestion, whereas constant prices may be more effective if the primary goal is to raise revenues (U.S. Department of Transportation, 2014). Set at a level to achieve an optimal reduction in congestion, constant tolls may generate more revenue than varying tolls, which would generally require a higher average level.

Similarly, while variable pricing can shift trips to off-peak times and can thus reduce traffic congestion, the effect may also be to increase the number of trips overall by making travel times shorter, and therefore more appealing. As a result, total GHG emissions and air pollution could increase, depending on policy design and the behavioural response of drivers.

day. Travel speeds during peak times increased from 45 km/h to 65 km/h in the central business district (Goh, 2002).

One risk of time-varying pricing systems is the potential for congestion at the specific times when rates change. In London, for example, a new traffic peak arose just after the fixed daily charging period ended each day (Santos et al., 2008). Other unexpected outcomes can also result: In Singapore, authorities observed motorists speeding up just before the start of a time period with higher rates. In response, the Land Transport Authority introduced graduated fee pricing during five-minute buffer periods (Chew, 2009).

Net benefits

Variable distance-travelled pricing policies can most directly align incentives with congestion problems, and so best improve the efficiency of road use. When congestion is greater, higher prices can ensure that only the most valuable trips are taken, thereby maximizing the value of road space. But when traffic is flowing well, lower prices can ensure that trips are not unnecessarily diverted. By better incorporating information about travel, pricing that varies over time and space can help increase the efficiency of a congestion pricing system (Verhoef et al., 1996). Similar to having broad coverage, dynamic prices are closest to "theoretically ideal" congestion pricing (Small & Verhoef, 2007).

Variable pricing can increase net benefits even when the policy has only narrow coverage. For example, parking policies that charge rates based on demand, or are priced at different rates depending on time and day, offer the most potential for efficiently influencing congestion (Shoup, 2005). As discussed in the San Francisco case study, for example, dynamic parking pricing allowed the city to establish the desired occupancy rates in the project areas of 60% to 80% by reducing the average parking meter price by 1% during the first year (Pierce & Shoup, 2013), and by 4% (at meters) and 12% (in parking garages) over the course of the pilot project (SFMTA, 2014).

In terms of administrative costs, however, fully dynamic pricing tends to be the most expensive. Adjusting prices in response to congestion levels—and communicating these varying prices to drivers in real time—is technically more complex. To date, fully responsive pricing schemes have only been implemented on several HOT lanes, although it could be practical in some cases to toll full facilities. However, obtaining up-to-date information on equipment and operating costs of fully responsive pricing systems is challenging owing to competitiveness concerns of private operators (de Palma & Lindsey, 2011).

Fairness

Variable pricing improves horizontal equity in several ways. It better aligns the incidence of costs and benefits: those drivers who pay the largest fee also receive the greatest benefits in the form of reduced congestion and shorter travel times. Variability can also reduce the distributional impacts of congestion pricing on businesses located within a congestion zone (Althaus et al., 2011). In contrast, a single, static price can discourage travel, leading to reduced visits and decreased business activity. These impacts, however, can be reduced when congestion is priced more stringently at peak hours.

The relationship between price variability and vertical equity is less clear. Lower-income drivers may have less flexibility in their travel schedules, and if they have fewer alternatives to driving to work (either because of location or time-of-day restrictions), they may be disproportionately affected by the policy (Ecola & Light, 2009). On the other hand, people with lower incomes tend to use public transit in greater proportions (Rajé, 2003). Santos and Rojey (2004) argue that road pricing can be regressive, progressive, or neutral depending on design and characteristics of individual cities. Looking at Stockholm's system, for example, where charges vary by time of day, given that higher income is correlated with higher travel costs and greater car use, Eliasson and Mattsson (2006) find that travel-cost increases for high-income groups are double those for low-income groups. In addition, they conclude that since congestion pricing revenue is invested in improvements in public transit, the overall policy is progressive.

Practicality

Pre-scheduled price variability (i.e., higher prices at typical peak traffic times) is relatively straightforward to implement and communicate. Fully dynamic pricing, however, can increase complexity in several ways, making both implementation and communication more challenging.

First, variable pricing increases the technical challenges of actually charging drivers. Dynamic pricing in particular requires additional resources to measure traffic flows, calculate rates, and inform drivers of current rates (U.S. Department of Transportation, 2008b). Yet, as discussed in Box 4, technology is changing quickly and these challenges may soon disappear. With location-tracking capabilities of the kind currently in smartphones, even existing technology costs may be lower than previously anticipated.

Box 4: Technology as an Opportunity Rather Than a Barrier

The days of labour-intensive toll booths are numbered.

Sophisticated technologies for road pricing can now be tailored to the specific design choice and policy objectives, and offer a wide range of benefits. Digital licence plate recognition, tag and beacon units (using microwave technology), and in-vehicle units (using GPS and GIS) make recording and tracking vehicle movements, and communicating data, easier than ever before (de Palma & Lindsey, 2011). And unlike their decade-old counterparts, new technologies are more accurate in detecting, charging, and verifying road use. The next generation of GPS devices, for example, will be accurate within a distance of one metre or less (Amos, 2014). In the future, the possibility of widespread "driverless" vehicles could influence the benefits of tolling by enabling travel by people who cannot drive (increasing the demand for road use) and by more effectively using existing road capacity, such as by permitting higher-speed traffic with fewer accidents.

The technological requirements of any chosen congestion pricing policy depend on the goals and objectives of the policy. Canadian cities predominantly use a combination of digital licence plate recognition and tag and beacon units, such as the MacPASS system in Halifax, the 407 ETR in Ontario, the A25 toll in Montreal, and the Port Mann Bridge in Metro Vancouver. But as location-tracking devices (e.g., smartphones and in-vehicle devices) become more common, new opportunities for smart and real-time technologies are emerging. For instance, Desjardins Insurance in Quebec now offers voluntary mobile phone-based GPS tracking to determine its insurance rates. If driving is determined to be safe (e.g., gradual acceleration), rates are lowered. One of the technologies used in Oregon's distance-travelled charging trial is paired with a similar insurance service.

Each technology involves important trade-offs, such as flexibility, scalability, privacy protection, and cost. Costs depend significantly on the level of complexity, system coverage, and existing infrastructure. But as with other electronics, the cost has fallen significantly over time and the marginal expense of adding additional users is small. The cost of running Oregon's distance-based program, for example, is expected to be 20% to 50% of total revenues, assuming 5,000 users; if the program reaches one million users, costs should be less than 5% of revenues (Oregon Department of Transportation, 2013).

Given its continued evolution, technology is no longer a barrier to implementing congestion pricing policies. Rather, new technologies offer a wide range of opportunities for integrating congestion pricing with other elements of the transportation network to generate system-wide efficiencies and benefits (Texas Transportation Institute, 2015).

Second, more variability can increase public opposition because it is more confusing and difficult to understand. Drivers may not like the uncertainty associated with the price of road access, particularly if price spikes occur unexpectedly in response to dense traffic. Bonsall et al. (2007) note that businesses in particular opposed the increased uncertainty from responsive pricing on the I-15 HOT lane in the United States, since they cannot control their exposure to the charges as easily as individual drivers. As shown in Section 3, San Francisco's experiment with demand-responsive parking pricing used a cap on the hourly price. While this cap likely increased the public's acceptance of the program, it also appears to have limited the policy's overall effectiveness. Well-designed price caps can nonetheless help to limit uncertainty while maintaining the majority of the benefits of dynamic pricing.

The technologies required for dynamic pricing may also raise privacy concerns, potentially increasing public opposition. However, these concerns appear to be less of a barrier in Canada than in the United States (de Palma & Lindsey, 2011; Lindsey, 2008).

4.4 REVENUE USE

How revenue generated by a congestion pricing policy is used, or recycled, has important implications for the policy's overall performance. Different approaches—for example, reducing taxes, funding infrastructure, or improving public transit—involve trade-offs associated with the performance and acceptability of the policy. As the revenues are a scarce resource, policymakers must make difficult choices about how to use them.

We consider four main approaches to revenue recycling. There are other possible uses of revenue, but the following four choices highlight the central trade-offs involved:

- **Invest in alternative transportation to personal vehicles** (e.g., public transit or bike lanes)
- **Reduce existing taxes** (e.g., fuel taxes, parking taxes, property taxes, sales or income taxes)
- **Invest in infrastructure** (e.g., roads and bridges)
- **Make direct transfers to households**

Local factors—in particular, the state of existing transportation infrastructure—also affect trade-offs between different approaches to revenue recycling. We highlight relevant factors in the assessment below.

Effectiveness

Of the four broad choices, using net revenues to fund alternative modes of transportation is often the best way to increase the overall effectiveness of the policy. Public transit, for example, is an option for drivers looking to avoid the congestion fee; enhancing public transit, therefore, makes it easier for drivers to respond to the price. Such was the case in London, which saw large improvements to already-extensive transit prior to the beginning of congestion

Table 2: Public Transit in Five Canadian Cities

RAPID AND EXPRESS TRANSIT	City of Toronto	Island of Montreal	Metro Vancouver	City of Calgary	City of Ottawa
Length of existing rapid transit lines	**83 km**	69 km	68 km	59 km	43 km
Length of existing rapid transit lines per million residents	32 km	37 km	29 km	**53 km**	49 km
Annual rapid transit trips per capita	**133**	93	52	74	104
Residents living within 1 km of existing rapid transit service	34%	**37%**	19%	21%	28%
Length of rapid transit lines opened in past 20 years	18 km	5 km	**44 km**	29 km	23 km
Length of rapid transit lines opened in past 10 years	7 km	5 km	20 km	**22 km**	9 km
Length of express bus lines opened in past 20 years	**87 km**	0 km	38 km	16 km	0 km

Source: Singer and Burda (2014).

charging, helping to make the London policy effective (Small & Verhoef, 2007). Timing, however, can be a challenge: investment may need to precede the introduction of congestion pricing so as to provide a viable alternative for drivers.

The extent to which public transit investments can improve the effectiveness of congestion pricing policy strongly depends on the quality of existing transit infrastructure. The biggest gains can be generated in cities in which existing transit capacity is the most strained by excess demand. Canada's large cities show considerable variability, as Table 2 shows. The differences between cities highlight differences in needs for new public transit as a complement to congestion pricing.

If revenue from congestion pricing is instead used to invest in new road infrastructure, it can sometimes actually *decrease* the overall effectiveness of the policy. New or improved driving capacity often unlocks "latent demand" for driving and can lead to increased traffic congestion. Rather, new roads must be part of a balanced approach to reducing congestion. Using revenue to reduce gas taxes could promote more driving—and thus traffic—relative to other revenue uses. Direct transfers to households, though perhaps achieving other objectives such as ensuring fairness for low-income households, are unlikely to have an effect on the amount of congestion.

Net benefits

Multiple approaches to revenue recycling could increase the net benefits of congestion pricing policies. The relative costs and benefits of different approaches are difficult to assess definitively, given the importance of various local factors.

Using revenue to invest in alternative modes of transport can increase net benefits. The availability of alternatives for drivers during peak periods influences the costs of reducing driving (Litman, 2011). Given the costs of congestion, improving the effectiveness of policy can maximize the benefits of reduced traffic, particularly in cities with insufficient public transit.

Using congestion pricing revenues to reduce income taxes can raise the overall net benefits of the policy (Parry & Bento, 2001). Reducing income taxes is unlikely to directly affect the efficiency of road use, but is more likely to improve the efficiency of labour markets. No existing congestion pricing systems currently allocate revenues to reduce income taxes.

Similarly, revenue invested in broader infrastructure could lead to productivity increases, particularly if existing infrastructure is limited or in poor repair. The Port Mann Bridge in Metro Vancouver is a concrete example of how new infrastructure was funded by a toll whose existence was likely necessary for the initial construction of the bridge. Access tolls can finance new infrastructure that would otherwise require increases in other taxes or would be difficult to finance.

Fairness

Revenue use has major implications for the fairness of congestion pricing policy. Different approaches to revenue recycling can impact fairness in different ways.

Investing revenue in public transit has mixed effects on fairness. It can increase horizontal equity, because it benefits those most impacted by congestion pricing (i.e., those shifting from driving to other modes of transit) (Ecola & Light, 2009). Yet, it also benefits other users of public transit, including those who would not have driven, even without the congestion price; this latter effect implies a cross-subsidy from drivers to non-drivers. Funding public transit likely increases vertical equity, given lower-income households rely more on public transit than do higher-income households (Rajé, 2003).

Using revenue to reduce other taxes will tend to decrease horizontal equity, because drivers pay the direct costs of the policy, but all taxpayers receive the benefits of the tax reductions. The breadth of pricing also plays a role: narrower pricing policy confers narrower congestion benefits that may or may not align with the broader benefits of tax reductions. Still, non-drivers do receive some indirect benefits from efficient road transportation. In terms of vertical equity, reducing other taxes might be progressive or regressive, depending on which taxes are reduced and how these reductions are tailored to different tax brackets.

Investing revenue in infrastructure can be a fair approach if the revenue is used to fund the building and operation of the specific infrastructure being used (i.e., roads or bridges). This approach essentially frames the congestion pricing policy as a user-pay model. The Port Mann and Golden Ears bridges in British Columbia, the tolled bridges on Autoroutes 25 and 30 in Quebec, and the 407 ETR in Ontario all represent Canadian examples of this kind.

Redistributing revenues through direct transfers to households via credit systems (for example, providing low-income travellers with credits redeemable for free access) can reduce burdens on low-income households (Ecola & Light, 2009). These direct transfers can be used to offset potentially regressive impacts of the congestion price itself.

Practicality

How revenue is used is a key factor affecting the public's acceptance of congestion pricing policies. Local preferences for how to use revenues, however, vary both within Canada and elsewhere.

Small and Verhoef (2007) note evidence suggesting that the Dutch prefer investments in road infrastructure, the British have a greater preference for public transportation, while in the United States, the preference is for road construction or tax reduction.

4.5 SUMMARY: POLICY GUIDANCE

Different design choices for congestion pricing policies—coverage, pricing, and revenue use—have different advantages and disadvantages. Table 3 summarizes the trade-offs discussed in this section. A green plus sign indicates a positive impact of a specific design choice on a given evaluation criterion, while a red minus sign indicates a negative impact. Where a question mark is shown, multiple effects make the net impact uncertain. A zero indicates no likely impact on the specific criterion. N/A designates that a given design choice is not applicable to the evaluation criterion.

Policy design is even more complex than is suggested by Table 3, given that local context in different cities also affects the trade-offs between design choices. What do these trade-offs mean for a city considering congestion pricing in practical terms? How should a city's local context be translated into policy design that is effective, cost-effective, fair, and practical? Identifying detailed, customized solutions for different cities is outside the scope of this paper. Yet based on the analyses and principles examined in this section, and information from interviews with local experts, the report's following section provides some practical policy suggestions for Canada's four largest cities.

Table 3: Evaluating Design Choice Trade-Offs

		Effectiveness	Net Benefits		Fairness		Practicality	
		Reducing congestion	Economic efficiency	Administrative efficiency	Horizontal equity	Vertical equity	Legal / jurisdictional	Public acceptability
Coverage: Broader Pricing		+	+	–	+	–	–	?
Pricing: Greater Price Variability		+	+	–	+	+	–	?
Revenue Use:	Public Transit	+	+	N/A	+	+	0	+
	Tax Cuts	–	+	N/A	–	?	–	+
	Infrastructure	–	+	N/A	+	–	–	0
	Direct Transfers	0	0	N/A	–	+	0	+

5 POSSIBLE CONGESTION PRICING SOLUTIONS FOR CANADA'S FOUR LARGEST CITIES

Congestion is a critical problem in Canada's cities. But is the nature of the problem the same from city to city? To what extent do the context and circumstances of individual cities affect the challenges—and the potential opportunities—for congestion pricing policy? And how can these factors inform policy design?

To explore differences across Canada, we interviewed key stakeholders in various parts of the country to gain insight into how to move forward with practical and effective congestion pricing in Canada. We also drew upon findings from new research gauging public opinion on traffic congestion and the role of congestion pricing in alleviating it (Abacus Data, 2015).

In our interviews, we focused on similarities and differences among the four biggest cities: Metro Vancouver, Calgary, Greater Toronto, and Greater Montreal.[5] Though we targeted practitioners and experts in four large cities, along with some people with nation-wide knowledge, the lessons that emerge also matter for other, smaller Canadian cities (see Box 5).

Four main themes emerge that help to define the barriers and opportunities faced by different cities: *geography*, *infrastructure*, *governance and institutions*, and *attitudes and culture*. While Metro Vancouver, Calgary, Greater Toronto, and Greater Montreal have much in common as they work to combat rising traffic congestion, they also have important differences along these dimensions.

Based on both the local context of each city and the design framework developed in Section 4, we outline a congestion pricing proposal for each of the four cities. Following Lindsey (2008), we focus on how congestion pricing "might be introduced in the next few years using established technologies." While these proposals follow logically from our analyses of local context and design trade-offs, other options may also be suitable. These are intended only as policy springboards to begin more detailed policy conversations in each city.

5.1 METRO VANCOUVER

Metro Vancouver's transportation network is at a turning point. The region suffers from one of the worst congestion problems in the country, and has an overburdened public transit system. A 2015 referendum rejected a proposal to fund road and transit projects via an increase in the sales tax in the region, leaving Metro Vancouver's transportation system in an uncertain state.

[5] For an overview of our interviewees, interview methodology, and interview questions, see Appendix.

Box 5: Congestion Pricing Would Also Be Effective in Smaller Cities

The rollout of the zone-based pricing policy in Gothenburg, Sweden, a city of approximately 500,000 people, illustrates that smaller cities can also benefit from congestion pricing.

After eight months of charging tolls to access the downtown core, traffic levels during peak periods declined by 12%, with residents switching to public transit, reducing travel frequency, and changing their travel destinations (Börjesson & Kristoffersson, 2015).

In the Canadian context, several medium-sized cities have serious isolated congestion problems. In Halifax, for example, regular congestion occurs on the seven roads and bridges that connect the downtown peninsula with the rest of the municipality (Althaus et al., 2011). The region has one of the lowest population densities in Canada, which results in people travelling significant distances on the region's sprawling network at peak commuting times (Statistics Canada, 2015b). Similarly, congestion in Ottawa-Gatineau is characterized largely by travel between its many suburban communities. Highway 417 cuts directly through Ottawa's downtown core and is often congested at peak times, along with bridges linking Ottawa and Gatineau and several major arterial roads (Moscato, 2015).

Victoria, Edmonton, Saskatoon, Winnipeg, and Quebec City are also medium-sized cities with their own isolated congestion problems that could be alleviated by well-designed congestion pricing policies.

The geography of Metro Vancouver is constrained and defined by northern mountains, the U.S. border, and the Pacific Ocean. In terms of land use and travel patterns, the region is considered *polycentric*, meaning the network of regional city centres results in "everywhere to everywhere" travel, as opposed to travel directed primarily to and from a single downtown core. Metro Vancouver is also home to the busiest port in Canada, with a growing volume of container truck traffic (Port Metro Vancouver, 2013). Growth in container volumes is projected to increase container truck traffic by 300% by 2020 (TransLink & Delcan, 2009).

Congestion in Metro Vancouver is largely a function of population growth and transportation infrastructure. Despite significant improvements and expansions, the capacity of the region's roads, bridges, and public transit has been unable to keep pace with the mobility needs of a growing population, which is expected to increase by approximately one million residents by 2041 (TransLink, 2013). Interviewee Chris Quigley noted that population growth poses a particular challenge for the public transit system.

Bridge and tunnel crossings are essential components of the region's transportation network, but also add to the region's daily traffic. A total of 20 bridges and one tunnel cross waterways between Vancouver and North Vancouver, Richmond and Delta, and Burnaby and Surrey, and serve as corridors between municipalities.[6] Because there are few high-volume roads, congestion or an accident will turn large areas, such as the North Shore, into gridlock. The main downtown peninsula is also separated by water bridges, a SeaBus crossing, and several roads that access the peninsula from the east.

> **"Commuting in Metro Vancouver is not centred around a single core; there are multiple nodes where people converge across the region. New town centres are being actively developed, so the traffic flows will shift accordingly. And the public transit system is now overloaded—buses often skip stops."**
>
> **—Mayor Greg Moore, Port Coquitlam, B.C.**

Metro Vancouver's governance and institutional framework for transportation policy and operations is very complex. The region comprises 21 municipalities, one electoral district (encompassing several unincorporated areas), one treaty First Nation, and the regional government of Metro Vancouver. But unlike in many other Canadian cities, the regional transit operator (TransLink) has signifi-

[6] The Cassiar Connector is a technically a tunnel as it goes under the roadway, but it does not link municipalities or cross water; as such tolling is not logical on this link.

cant authority over the region's roads and public transit infrastructure.

Culture and attitudes toward driving in Metro Vancouver are also complex. According to a new public-opinion survey, 70% of Metro Vancouver residents reported that current traffic congestion hinders their mobility (Abacus Data, 2015). Yet its residents decidedly voted no in the 2015 plebiscite on whether to increase the sales tax to help fund the mayors' council's $7.5-billion package of infrastructure and transit improvements. The same survey results also suggest that traffic congestion was not a major factor for most referendum voters. Regional variations are an important factor: while residents of downtown Vancouver have access to multi-modal transportation, including walking, cycling, and transit infrastructure, many residents in surrounding municipalities lack access to such choices, and therefore rely on cars.

Metro Vancouver policy option: Variable bridge and tunnel tolls

Considering the region's constrained geography, polycentric travel patterns, and complex governance structure, applying variable pricing to the region's bridges and tunnels that cross waterways is a practical option to reduce regional congestion. Mobility pricing is not a new concept for Metro Vancouver (e.g. TransLink, 2013; Cayo, 2012).

Tolling the region's bridges and tunnels could be an effective approach for several reasons. Owing to the high number of water crossings and lack of land-based alternatives, tolls on the region's water crossings would intercept a large portion of traffic and would be expected to reduce congestion and its subsequent air pollutants and GHG emissions (Lindsey, 2008; Deloitte, 2010). As reinforced by our interview with members of the B.C. Ministry of Transportation & Infrastructure, the provincial government would need to change its existing policy on tolling, which limits the application of tolls to cover infrastructure costs for projects that increase capacity and have a reasonable un-priced alternative (Government of British Columbia, 2003; Deloitte, 2010). Prices that vary by time of day, or even dynamically in response to demand would be most effective in specifically targeting peak congestion periods and reducing bottlenecks.

The region's geography, governance structure, and commuting patterns make other approaches to congestion pricing challenging in the shorter term. Unlike Toronto and Calgary, Metro Vancouver lacks long stretches of controlled-access highways and an existing network of HOV lanes. As argued by Lindsey (2008), this makes HOT lanes an ineffective option for Metro Vancouver. However, a comprehensive distance-based system is a potential long-term option. See Box 6 for additional discussion.

Box 6: What About Distance-Based Pricing?

Comprehensive distance-based pricing is a possible long-term option for Metro Vancouver (and other Canadian cities).

This pricing system would charge all drivers within Metro Vancouver a per-kilometre fee that could vary by day, time, and even the emissions intensity of the vehicle. Of all available pricing options, a comprehensive distance-based system is viewed as the most equitable, because each driver pays directly for the time and use of the roads, no matter where they live in the region (Deloitte, 2010).

Unlike bridge tolling, a comprehensive distance-based option has not yet been implemented anywhere in the world. The existing distance-based program in Oregon is similar; however, drivers have the ability to opt in to the program, and the primary objective is to raise revenue rather than to reduce congestion. By contrast, a comprehensive distance-based system that specifically targets congestion in Metro Vancouver would require a higher level of coercion. Each vehicle would need to be fitted with an on-board unit using GPS technology, and would necessitate tracking the time and distance of travel from each vehicle and communicating this information to the pricing authority.

Even though people commonly carry electronic devices that collect and store information regarding their location, privacy concerns are expected to be a major point of contention in implementing distance-based pricing. TransLink and Metro Vancouver have supported the idea of a comprehensive distance-based system as a long-term option, but it is unlikely to be a realistic policy option in the immediate future.

While bridge and tunnel tolling are technically feasible, a pilot program would require substantial physical resources in the form of sensing or identification equipment. As a result, any pilot project would require detailed study and careful design. The opportunity is to open dialogue on pricing and what a pragmatic option could look like.

5.2 CALGARY

Road congestion in Calgary is shaped by its unbounded geography and low population density. Unlike many cities in Canada, the city limits of Calgary are unrestrained by natural or man-made barriers, enabling the city to expand. With a large land base, the historical direction of Calgary's development encouraged the expansion of suburbs while fostering a dense downtown core.

With such dispersed geography, road and rapid transit infrastructure stand out in Calgary. Residents rely on the extensive network of freeways and major arteries that criss-cross the city. One major network is the Calgary ring road, which is a series of provincially owned highways that run around the city's perimeter. The second major network is the municipally owned "skeletal road network," comprising a series of freeways and major arterial roads designed to provide free-flowing transportation through and around the city (City of Calgary, 2015b).

Calgary has significantly increased its funding for transportation infrastructure in the past decade, and public transit has received a large portion. Yet even with consistent year-on-year ridership growth, Calgary lags behind Toronto and Montreal in the number of transit trips per capita and the number of residents living within one kilometre of rapid transit, as shown earlier in Table 2.

In terms of governance and institutions, Calgary, like other Canadian cities, contains overlapping jurisdictions with the provincial and municipal governments. The Alberta government—which, as highlighted by interviewees, would currently consider tolling only new highways—is responsible for planning the region's transportation network and is directly responsible for maintaining provincial highways. Increasing the capacity for high-occupancy vehicles is a major planning priority for the city. Outlined in its 2009 transportation plan, the city developed and proposed the Primary HOV Network, which includes plans to build more than 440 lane-kilometres of HOV lanes for Calgary's biggest corridors over the next 10 to 60 years (City of Calgary, 2009).

Despite ongoing efforts to build multi-modal transportation alternatives, driving is still the most prevalent mode of transportation in Calgary. Approximately 77% of Calgary's population commute to work by car or truck, compared with roughly 70% in Montreal, Vancouver, Toronto, and Ottawa-Gatineau (Statistics Canada, 2011; based on census metropolitan areas), and 80% of those commuting car trips are made by single-occupant drivers (City of Calgary, 2012). In addition, since Albertans have for many years paid the lowest provincial tax rates in the country, Calgarians may be more averse to road pricing than residents of other Canadian cities (Zdeb, 2015).

> **"The biggest challenge [with congestion] is getting people from their homes to their offices in a reasonable amount of time. […] It's gone beyond being an economic issue; it's become an identity issue. [People] end up living in places they don't want to live, or working in places they don't want to work because of congestion."**
>
> **—Interviewee**

Calgary policy option: HOT lanes

Calgary's low density and lack of familiarity with road pricing makes HOT lanes a very practical policy option. Based on the extensive network of freeways in Calgary, a number of recent reports recommend HOT lanes as the best option to increase time-savings for commuters, with relatively low implementation costs (Graveland, 2014; Brunnen, 2014). A recent report by the city evaluated 16 different revenue-generating options over several criteria (e.g., efficiency, equity, sustainability), and HOT lanes are recommended as one of the best ways to reduce congestion, generate modest revenue, and increase the efficiency of the transportation network. A similar recent report by the Manning Foundation identifies five major roadways as suitable for HOT lanes: Crowchild Trail, Glenmore Trail, Deerfoot Trail, 14 Street South, and Stoney Trail (Brunnen, 2014). Congestion pricing could also complement Calgary's ongoing efforts to expand public-transit capacity, influencing residents to make better use of the growing transit network.

Because of the city's low density, high levels of car use, and moderate use of public transit, broad congestion pricing may not actually have a significant effect on Calgarians' driving behaviour. And given the city does not have a clear natural cordon around the downtown area, establishing a zone-based congestion pricing system would likely be challenging (Brunnen, 2014).

The existing legislative context in Alberta prohibits using road tolls. To implement HOT lanes in Calgary, the provincial government would thus need to coordinate with the City of Calgary and alter legislation to permit an effective pricing scheme.

Another important consideration is public perception. Residents have very limited experience paying directly for road use. As such, building HOT lanes may be the most pragmatic pricing option for the Calgary context, as it maintains personal choice for drivers while still tackling the growing problem of traffic congestion.

While HOT lanes are technically feasible, a pilot program would require substantial physical resources in the form of sensing or identification equipment. As a result, any pilot project would require detailed study and careful design. The opportunity is to open dialogue on pricing and what a pragmatic option could look like.

5.3 GREATER TORONTO AREA

As Canada's largest city, the GTA likely has the country's biggest problem with traffic congestion. Fully 49% of Toronto's survey respondents identified traffic in the GTA as a "truly bad problem" (Abacus Data, 2015).

In terms of geography, the GTA is *polycentric*, with multiple hubs of activity and diffused congestion problems with drivers travelling between the various hubs in different directions. Compared with Metro Vancouver, which has a variety of natural and man-made constraints on development, the GTA is relatively unbounded (except on the south by Lake Ontario). Greater Toronto's transportation system relies heavily on the highly congested 400-series freeway network, which includes the privately operated and variably tolled Highway 407. Congestion is widespread across all types of roads, but highways are critical arteries for commuting throughout the densely populated region.

Two kinds of infrastructure stand out in Toronto: HOV lanes and transit capacity. A report from the Government of Ontario (2007) laid out plans for a 450-km network of HOV lanes to be constructed by 2031, and to be built with new capacity rather than by converting existing lanes. The same report also included a commitment to convert selected HOV lanes into HOT lanes. Following the implementation of a temporary expanded HOV network during the 2015 Pan Am Games, the Ontario government announced its intention to implement HOT lanes in the GTA, renewing and updating the 2013 provincial budget commitment (Moore & Hui, 2015). The City of Toronto (2015) subsequently released a report considering tolls on the Don Valley Parkway and Gardiner municipal highways.

The GTA's phenomenal growth in population has not been matched by an equivalent expansion in public transit infrastructure, which is uncommon for cities in the developed world. Its public transit systems are highly overburdened: the region has the greatest number of annual transit trips per capita, but the second-lowest capacity per capita (as measured by length of lines), as documented by Singer and Burda (2014).

> **"Ontario recently, with success, has focused on getting funding for transit. I would like to see strong discussion go one step further to really challenge and drive maximum productivity from the significant investments now being made."**
>
> **—Metrolinx's Michael Sutherland**

In terms of governance and institutions, overlapping jurisdictions of transportation policy in Ontario makes achieving coherence and consistency challenging. The province owns the 400-series of highways. Metrolinx, an agency of the Ontario government, manages and integrates road transport and public transit in the Greater Toronto and Hamilton Area. While Metrolinx is legally empowered to levy tolls on local roads, it would still require a special regulation to do so, and the provincial government would need to be involved (Lindsey, 2008).

As in Calgary, driving is deeply embedded in the attitudes and culture of GTA residents, and concerns about traffic congestion are extremely high. In a 2015 survey on public opinion regarding traffic congestion, 89% of respondents expressed serious concerns about traffic—the most of any city considered in the survey (Abacus Data, 2015). In 2013, a survey on funding tools found moderate support for congestion pricing such as HOT lanes (with 49% support) and central core charges (46%), and wide support for dedicated use of these revenues to fund the GTA's needed transit expansion (92%) (Ipsos Reid, 2013). As in Metro Vancouver, suburban drivers in the GTA rely more on driving, with less access to alternative modes of transit. Nevertheless, the existence of the well-used private 407 ETR, and an upcoming publicly owned extension to the tolled route, suggests a rising degree of acceptance for congestion pricing in the region.

Greater Toronto policy option: Toll routes and HOT lanes

Converting HOV lanes to HOT lanes or building new HOT-lane capacity on the provincially owned 400-series of highways could be a practical option to price and reduce congestion in the area. In addition, using a pricing system that responds dynamically based on demand could help to improve vehicle flow on these key travel corridors, with implications for traffic throughout the city.

Lindsey (2008) and Dachis (2011) both propose the conversion of existing and planned provincially owned HOV lanes to HOT lanes. This previous research, along with knowledge from our interviews with city experts, suggests that this is a good near-term option for incorporating congestion pricing into a mobility strategy for the GTA. It can be done as a trial and can be seen as a first step, with more comprehensive pricing introduced as population and congestion continue to grow. A viable longer-term option could be full tolls on the same network of 400 highways, as proposed by the Pembina Institute (Srivastava et al., 2015).

HOT lanes on provincial highways likely provide the most straightforward opportunity to bring congestion pricing into the GTA's congestion reduction strategy (Dachis, 2011). Given Toronto's geography, a cordon is impractical, and a distance-travelled pricing approach is both technically and politically challenging. Further, if Ontario continues to expand its network of HOV lanes, in line with its 2007 plans, permitting them to be built as HOT lanes instead would likely be a superior choice, as HOT lanes can enable highways to be used by more people (Safirova et al., 2003). As well, HOT lanes respond to concerns regarding fairness, as unpriced options remain available. Focusing on provincial roads exclusively could also reduce coordination challenges that would come from tolling both local and provincial roads. Alternatively, should the City of Toronto decide to implement tolls on the Don Valley Parkway and Gardiner municipal highways as per the above-mentioned 2015 report, coordination would be required to ensure that municipal and provincial approaches are complementary.

While toll routes and HOT lanes are technically feasible, a pilot program would require substantial physical resources in the form of sensing or identification equipment. As a result, any pilot project would require detailed study and careful design. The opportunity is to open dialogue on pricing and what a pragmatic option could look like.

5.4 GREATER MONTREAL

Congestion is widespread throughout the Island of Montreal and on connectors to surrounding off-island areas, which together make up the Greater Montreal region. Institutions governing regional transportation are in flux, and an aging road network—and especially the upcoming replacement of the Turcot Interchange and the Champlain Bridge—create some uncertainty for the future of the regional transportation system, and for moving forward with congestion pricing policies.

Two aspects of geography are notable in Greater Montreal: the natural cordon formed by the Island of Montreal, and extensive commuting on and off the Island. While there are multiple centres of activity, the Island boundary and its constraints have led to development that is less polycentric than in Metro Vancouver or the GTA. The Island is connected to the mainland and other surrounding islands by 18 bridges (one of which is partially a tunnel, and some of which include rail lines and pedestrian or bike routes). Of the 18 bridges, three are federally owned, including the Champlain Bridge.

Montreal's transportation infrastructure stands out from other major Canadian cities, with two key factors shaping the regional transportation system and efforts to manage congestion. The public transit system is relatively good, but the urgent need to replace aging road infrastructure has generated major funding challenges, as well as difficult-to-predict congestion due to ongoing repair and maintenance. A member of a government agency in Montreal noted that upgrading the city's aging infrastructure is indeed a high priority. Two bridges in the region are tolled. Both have private-sector involvement and both aim to provide good vehicle flow, but only one features rates that vary by time of day.

Greater Montreal is considering governance and institutional changes to centralize public transit and urban planning decision-making. Under the proposed plan, the provincial government would abolish the existing Agence métropolitaine de transport, replacing it with two new institutions. The first would integrate several off-island transit agencies into a new group called the Réseau de transport métropolitain. The second, the Agence régionale de transport, would be responsible for long-term planning and would include mayors from the metropolitan region along with other experts (Magder, 2015).

Historically, Montreal's policy has been coherent in its objectives—for example, with the regional gas tax implemented to fund transit infrastructure. But more recently, governance and financing issues, with inconsistencies among governments and a lack of integrated visions for transportation and transit, have exacerbated political and public barriers to congestion policy.

> **"I don't think it's a good idea to have many different tolls in the Montreal region with as many different companies and technologies to charge vehicles. How can we build a global vision for road planning and pricing in Quebec? If I pay for the Champlain Bridge, I don't see why I shouldn't pay for Highway 20 or Highway 15. We will have to harmonize all prices and technology one day."**
>
> **—Jean-Philippe Meloche, professor, Université de Montréal**

Challenges with aging road infrastructure permeate the attitudes and culture surrounding transportation in Greater Montreal. Interviewees in Montreal, for example, emphasized that the city's deteriorating infrastructure poses a serious problem for transport of both goods and people and is a high priority locally, noting that this concern may take precedence over traffic congestion. Non-recurrent congestion (which is costly because of time delays and low travel-time reliability) is perhaps more of an issue in Montreal than in other Canadian cities, mostly as a result of the persistent and widespread road repairs.

Despite local opposition to the planned toll on the new Champlain Bridge, the two new bridge tolls on Autoroutes 25 and 30 are well used (with one using time-varying pricing). And with the region's modest history of tolling (some bridge tolls existed until 1990), current acceptance of tolling may be reasonable.

Greater Montreal policy option: Variable bridge tolls

The natural cordon formed by the Island of Montreal provides an opportunity to relatively easily implement congestion pricing in the metropolitan region. Reducing congestion on the surrounding bridges, which are key choke points for traffic, can lead to reduced congestion on the Island, in the dense downtown core, and in surrounding areas off-island. Targeting the pricing policy to congested areas via the limited number of the Island's access points makes zone-based pricing more straightforward than it would be in Toronto or Calgary. Moreover, Greater Montreal is less polycentric than Metro Vancouver, with the downtown core a major hub for business. Significant traffic comes from commuters driving in from off-island. Customizing breadth of policy to this geographic context could thus target congestion zones with relatively low administrative costs.

As with our proposed option for Metro Vancouver, tolls that vary by time of day, or even dynamically in response to demand would be most effective for reducing congestion while minimizing the costs of the policy for drivers.

Concerns around the city's aging road infrastructure—and the associated delays of ongoing construction—could have implications for the timing and acceptability of implementing congestion pricing. Residents may be more supportive of congestion pricing if infrastructure problems are also addressed. This could suggest infrastructure investments as an appropriate approach to revenue recycling in the Montreal context.

Recent research on pricing road access for Greater Montreal has led to mixed recommendations. Lindsey (2008) similarly proposes a cordon charge around the Island of Montreal, noting how such a zone-based scheme could effectively target the most significant congestion issues. Research conducted as part of a 2014 Quebec fiscal review is also in support of tolling the network of 18 bridges around the Island as a medium-term option, indicating that the province should work with the federal government on harmonizing tolls on the three federally owned bridges (Gagnon et al., 2014).

On the other hand, Boulenger et al. (2014) and the Institut de développement urbain du Québec (2015) consider a range of direct road-use pricing options, and have come out in favour of distance-travelled pricing, which could also effectively target congestion in the region. However, both studies have approached the subject primarily from the point of view of revenue generation for financing infrastructure, as opposed to congestion reduction, which is our primary focus.

The City of Montreal's 2007 and 2008 transportation plans have expressed support for user-pay charges, and considered the possibility of tolls on bridges around the Island, although such plans do not appear to be on current agendas. Still, one of the bridges already has a toll (on Autoroute 25) and, as already noted, the new Champlain Bridge is scheduled to be tolled.

While bridge tolling is technically feasible, a pilot program would require substantial physical resources in the form of sensing or identification equipment. As a result, any pilot project would require detailed study and careful design. The opportunity is to open dialogue on pricing and what a pragmatic option could look like.

5.5 SUMMARY

This section develops congestion pricing policy proposals for Canada's four largest cities. As noted, these proposals follow logically from our analyses of local context and design trade-offs. They illustrate how local context affects design choices and trade-offs between different options. However, they are not intended as formal recommendations. Additional technical factors not considered here might also be critical. And other approaches to congestion pricing may also be suitable.

These initial policy proposals could, however, help to begin more detailed policy conversations in each city. They could also help to inform the development of congestion pricing time-limited pilot projects. As we discuss in the subsequent sections, phasing in congestion pricing—and in particular, testing policy through finite trial periods—can be a critical factor in effective policy implementation.

6 PRINCIPLES FOR IMPLEMENTATION

The design of congestion pricing policy is most successful when customized to the circumstances of individual cities and regions. Successful policy, however, is not just a matter of design, but also *implementation*. How policy is rolled out can play a key role in overcoming some of the barriers identified in Section 4, particularly public attitudes.

Both the literature on congestion pricing and our interviews with experts across the country highlight the importance of implementation details. And while some customization across jurisdictions is likely appropriate, some general principles also exist. This section lays out six principles for policy implementation. Overall, they suggest that implementation is not a simple, one-time policy announcement, but instead a deliberate *process* over time.

6.1 DEFINE OBJECTIVES CLEARLY

Policy should establish clear, explicit, and relevant objectives (Eliasson, 2010; Althaus et al., 2011). Objectives serve several purposes, and set up the principles that follow. First, clear objectives focus design choices. Congestion pricing can have multiple objectives, and some design choices can support one objective (e.g., reducing congestion) while being a detriment to another (e.g., raising revenue). Second, they establish consistent messaging as to the policy's rationale, enabling clear communication with stakeholders to build acceptance. Third, they provide a benchmark against which to evaluate the policy's success. Such evaluation is essential in order to adjust the policy over time to improve performance.

6.2 ENGAGE AND COMMUNICATE WITH STAKEHOLDERS

Althaus et al. (2011) note:

> Decision-makers cannot just decide in favour of a congestion charge, announce its implementation, and think reduced congestion will automatically follow. Care and timing must be paid to incorporating the right timing, communication, and consultation strategy for each jurisdiction, circumstance, political will, and community mood. (p. 553)

In short, part of the process of implementation is engaging and communicating with those most affected by congestion pricing.

In our interviews, Greg Moore, the mayor of Port Coquitlam, emphasized this point, noting the importance of clearly communicating the benefits of policy for individual drivers or companies in terms of personal and concrete savings. People need to see how and where the revenues are being used to benefit them. Another interviewee suggested framing the policy's benefits in terms of price and time: communication efforts should help drivers understand they are not paying to be able to go somewhere, but rather to get there *more quickly*. And TransLink's Chris

Quigley mentioned that it is important for people to recognize that society *already* accepts demand-based pricing policies in many areas of the economy (for example, utilities, movies, hotels, and airlines) and that congestion pricing is a logical extension of such practices.

How these benefits are framed also matters, and depends on local priorities. To build public support in Stockholm, for example, that city's successful congestion pricing policy was framed mostly around environmental benefits (Eliasson, 2010).

6.3 PHASE IN POLICY OVER TIME

Timing appears to be a critical factor for successful policy implementation. Most fundamentally, implementing a policy gradually can help build public support (Lindsey, 2007; Eliasson, 2010). De Palma et al. (2006) and Verhoef et al. (2008) highlight the importance of "implementation paths" as a sequence of policy measures, overcoming barriers to policy in stages.

The crucial implication here is that policy design need not be static: it could become broader or more variable, for example, over time. Priorities for revenue recycling might also change over time. A pathway approach might optimize design for practical concerns in the short term to overcome implementation barriers but transition to more effective and cost-effective policy over time. Singapore's pricing policy, for example, evolved in this way. Initially, congestion was priced and enforced manually, but the policy transitioned to an electronic approach as technologies evolved and comfort with the policy increased (Goh, 2002).

Starting with a demonstration project or trial period is a particularly effective way to build public support. Congestion pricing can generate concrete benefits for drivers in the form of reduced traffic congestion and saved time. The best way to communicate these benefits is to demonstrate them through experience. A key lesson from Stockholm's experience is that a trial period can greatly increase levels of public support (Eliasson, 2010).

> **"People need to learn by experience; for now they have experience not paying as they drive and they like that. They don't have experience with pay-as-you-go, so they will oppose that. A pilot program for mobility pricing that is testable, reversible, and verifiable could help to overcome such fears of the unknown—no amount of reports and commentators will change things until it becomes tangible."**
>
> **—Anthony Perl, professor, Simon Fraser University**

The timing of public engagement also matters. Manchester and Edinburgh, for example, held referendums on congestion pricing policy before implementation, and the policies were rejected. Stockholm, on the other hand, held a referendum after the trial policy had been in place for a year, and the policy was broadly supported (Eliasson, 2010). The trial period gave voters more complete information on the system by the time of the referendum.

6.4 COORDINATE DECISION-MAKING

As discussed in sections 4 and 5, overlapping jurisdictions can create challenges for policy implementation. Coordination between provincial and municipal governments as well as local transit authorities can be complex, though it is almost certainly necessary. Clear objectives can be harder to define. And coherent incentives across different modes of transit and different policy instruments can be hard to coordinate, leading to challenges for effective and cost-effective policy (de Palma et al., 2006). For example, congestion pricing does not necessarily require price changes for public transit, although the scope for users to substitute between driving and public transit suggests that some coordination on this front may be valuable.

6.5 EVALUATE AND ADJUST POLICY OVER TIME

The design and implementation of congestion pricing policy is almost certainly an iterative process. As a result, clear processes for evaluating the performance of policy and adjusting its design over time are essential (Eliasson, 2010). Collecting data—both before and after a policy has been implemented—is necessary for evaluating the effects of congestion pricing.

6.6 CONGESTION PRICING IS BEST IMPLEMENTED AS PART OF A POLICY PACKAGE

Congestion pricing is likely to have its greatest impact when accompanied by complementary non-pricing measures—for example, road and transit improvements that improve alternatives for drivers (Verhoef et al., 2008). The U.S. Department of Transportation (2008a) shows how complementary actions and technologies "(a) extend the benefits of congestion pricing strategies to those directly and indirectly affected, (b) improve public acceptance of congestion pricing strategies, and (c) improve the value of existing travel options available to individuals." (p. 3)

In particular, other measures can complement congestion pricing by affecting driver behaviour through information or behavioural cues. For example, they can seek to influence the behaviour of travellers en route, via roadside message signs updated with current traffic conditions and suggested routes, and radio traffic reporting. They can influence them before travel via web and telephone-based traffic services. Or they can influence vehicle flow directly through responsive variable speed limits, ramp metering (for regulating the flow of traffic that enters highways), adaptive signal control, and automated vehicle location for transit (U.S. Department of Transportation, 2008a).

Several additional complementary policies must be examined when considering congestion pricing policies. These include changes to transit pricing, encouraging bicycling, staggering of work hours by employers, promoting teleworking, and reforming public and employer-provided parking spaces (Arnott et al., 2005; Shoup, 2005).

7 SUMMARY AND RECOMMENDATIONS

This report has assessed the costs of congestion for commuters, the economy, the environment, and for Canadian cities overall. It has examined the merits of congestion pricing policies, and has explored international and domestic policy experience in implementing such policies. It has evaluated the trade-offs between different design choices, and shown that different contexts naturally lead to different design choices. Finally, it has laid out principles for smart policy implementation.

7.1 SUMMARY

This report has three main, overarching findings.

Traffic congestion is a growing problem in many of our cities, imposing significant costs on Canadians

Congestion on our roads and freeways leads to wasted time for commuters and goods movement. Given the importance of the movement of goods and people through our cities, this lost time translates into a less efficient economy. Congestion also affects choices about where people live, undercutting the ability of cities to attract businesses, jobs, and workers. Finally, congestion increases air pollution from vehicles with corresponding health implications for Canadians.

Congestion pricing is an essential—but missing—piece of smart transportation policy

Congestion pricing is an ecofiscal policy that prices road use or parking with the aim of reducing costly traffic congestion. A growing body of evidence and policy experience suggests that congestion pricing works, particularly as part of a broader policy package. When designed well, it reduces traffic congestion and creates net economic benefits both for the economy as a whole and for individual drivers.

The traditional approach to dealing with traffic congestion has been to expand public transit and to build more roads. These policies are key parts of the transportation puzzle: they increase the overall capacity of the transportation system and can reduce congestion in the short term. In the absence of congestion pricing, more drivers will ultimately fill this increased road capacity, and congestion may not be reduced in the long term. Moreover, the building of new road infrastructure to meet growing demand is constrained by land-use policy and increasingly stretched government budgets.

Congestion pricing is therefore the crucial, missing piece of a broader, coordinated package of policies to create greater mobility for a growing urban population. More public transit, roads, and cycling infrastructure provide drivers with alternatives, making it easier for them to respond to the congestion price by changing their behaviour. They are essential complements to congestion pricing. But without addressing the fundamental issue of misaligned incentives around free access to roads, traffic congestion in Canadian cities will only get worse.

Despite the evidence of its potential benefits, Canada has very limited experience with congestion pricing. The lack of public understanding of the benefits from congestion pricing remains an important barrier to implementing these policies.

The design details of congestion pricing policy matter

Congestion pricing is not a one-size-fits-all policy solution. Different cities face different types of congestion problems, and tailoring policies to local circumstances is critical for success. Policy design includes a range of choices. Should pricing be narrowly targeted or broadly applied? That is, should it price access to some roads, to all roads, to parts of roads, or even to parking? How should the price vary? Should it be higher at times of peak traffic, or even vary dynamically in response to real-time traffic levels? How should revenue from the policy be used? Smart policy design can reduce congestion, improving efficient transportation and travel outcomes for all travellers. It can also ensure that low-income travellers are not disproportionately affected. But the specific details of effective, cost-effective, fair, and practical policy solution will vary from city to city.

7.2 RECOMMENDATIONS

What then, are the next steps for reducing traffic congestion in Canada? Congestion pricing is increasingly needed in our cities. To demonstrate the benefits of congestion pricing and test policy design, we make four recommendations.

RECOMMENDATION #1: Major Canadian cities should implement congestion pricing pilot projects, customized to their local context

As illustrated by the case studies from Stockholm, Oregon, and San Francisco, trial periods for congestion pricing are low-risk policy initiatives. They can be voluntary for drivers, as in Oregon; take place for a limited time, as in Stockholm; and apply to a narrow scope of drivers, as in San Francisco.

Yet the benefits of such trials could be huge. If well designed, they can demonstrate the concrete benefits that congestion pricing can deliver. They can also provide opportunities for learning about how well different policy designs work in different contexts, thus allowing policy design to evolve and improve over time.

Municipalities best understand their own congestion context and should play a major role in designing pilot projects. They should design their pilot projects according to their unique policy objectives and their local geography, governance, infrastructure, and attitudes and culture. Different trial policies are not only more likely to succeed when customized to local context, but can also provide more information to other Canadian cities regarding what works and what does not.

The four proposals for congestion pricing policies for each of the country's four largest cities outlined in this report could form the foundation for time-limited trials in each city. The details of each proposal draw on lessons that emerge from experience with congestion pricing in other jurisdictions, take into account local context (gauged in part from interviews and polling), and consider key elements of policy design. They are not recommendations in and of themselves, but instead are intended as policy springboards to kick-start more detailed policy conversations in each city.

- **Metro Vancouver** has constrained geography bounded by mountains and ocean, polycentric travel patterns with multiple hubs of activity, and a complex governance structure with involvement from multiple municipalities and the provincial government. Applying variable pricing to each of the region's bridges and tunnels that cross waterways would be one way to price access to key driving arteries to reduce regional congestion.

- **Calgary** has low density, a lack of familiarity with congestion pricing, and more localized congestion problems. In this context, HOT lanes could be practical to implement, provide unpriced alternatives, and reduce congestion in key locations.

- **The Greater Toronto Area** has polycentric travel patterns with drivers travelling between multiple hubs in multiple directions and relatively unconstrained geography. Converting HOV lanes to HOT lanes or building new HOT-lane capacity on the provincially owned 400-series of highways—a backbone of the regional transportation network featuring the privately operated and variably tolled Highway 407—would be a practical approach for reducing congestion in the area.

- **Greater Montreal** has extensive commuting to and from the central Island of Montreal; relatively widespread congestion; an existing, time-varying toll on the Autoroute 25 bridge connecting the Island; and plans to replace—and toll—the aging, highly used, and federally-owned Champlain Bridge. The natural cordon formed by the Island provides a practical opportunity to implement variable pricing on the full array of surrounding bridges and tunnel, harmonizing tolls and reducing congestion throughout the area.

RECOMMENDATION #2: Provincial governments should initiate, enable, or facilitate congestion pricing pilot projects

Provincial governments can play multiple roles in enabling congestion pricing. First, not all roads are municipally owned and operated. In some situations, it is provincial governments that should directly implement congestion pricing policies. We considered approaches for Toronto, for example, that would price access to all or some lanes on the provincially owned 400-series freeways. While coordination with the municipal government would be essential, the province should implement the congestion pricing policy.

Second, provincial governments should play a coordinating role. A key governance challenge in many urban areas (for example, Metro Vancouver and Greater Montreal) is the diverse collection of municipalities with highly linked and overlapping transportation corridors.

Finally, provincial governments should provide municipalities with explicit authority to implement congestion pricing policies. The existing legal framework for implementing road pricing in Canadian municipalities is unclear and is complicated by overlapping jurisdictions. Generally, most municipalities are unable to implement broad congestion pricing on their own without changes to provincial policy. Provincial governments should reduce the existing ambiguity and make space for municipal policy by passing explicit legislation permitting municipalities to implement these policies.

RECOMMENDATION #3: The federal government should help fund pilot projects

Funding for congestion pricing pilot projects remains a barrier. Physical and digital infrastructure will be required to set up, monitor, and enforce the pricing policy during the trial period. While revenue could be generated, the scale of this revenue is uncertain and depends on the details of how the policy is implemented. Municipalities have very limited revenue sources and could face significant financial challenges in initiating pilot projects.

Federal funding to establish pilot projects would generate benefits for Canadians well beyond the individual municipalities involved in the project. As discussed below, evaluation of these projects would lead to valuable lessons learned about congestion pricing policy design and implementation that could be applied in other Canadian cities. Additionally, the cross-country benefit of efficient goods movement means that the federal government has a direct interest in supporting regional congestion pricing.

Support from the U.S. federal government played an important role in at least two of the American case studies examined in this report. Federal support helped enable the parking-pricing trial period in San Francisco as well as helped finance the development of Minnesota's HOT lanes.

RECOMMENDATION #4: Governments should carefully evaluate the performance of pilot projects, communicate the results broadly, and incorporate lessons learned into future mobility policies

The full benefits of pilot projects can only be realized if they are monitored over time, with data from before and after the project is implemented. The projects should be set up so that the impact on congestion, and also the overall administrative costs, can be measured and assessed. This analysis can help to communicate new, city-specific information about the efficacy of congestion pricing to stakeholders and to the general public. Demonstrating policy success can be a powerful tool for building public support.

This data-driven evaluation of the policy should be used to inform next steps. If the policy does not perform as well as anticipated, its design can be adjusted over time to respond to problems, or the policy can be terminated. If, on the other hand, the policy performs well, it can be expanded more broadly. Both the benefits and the costs of the policy should inform subsequent policy decisions.

Pilot projects are only a first step in addressing Canada's congestion problems. Yet as cities grow and congestion problems build, a starting point for smart policy is desperately needed. Demonstrating the effectiveness of congestion pricing on a small scale can create a launching pad for creating a transportation system that gets prices right—a transportation system that fosters cleaner air and more liveable cities, and ensures people and goods move efficiently rather than wasting time in traffic.

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APPENDIX:
OVERVIEW OF INTERVIEWEES, INTERVIEW METHODOLOGY, AND INTERVIEW QUESTIONS

To explore differences across Canada, we interviewed key stakeholders throughout the country to gain insight into how to move forward with practical congestion pricing in Canada.[7] While Canadian cities have much in common as they work to combat congestion, they also have important differences across factors, including geography, governance, infrastructure, and culture and attitudes. What we heard informed our policy recommendations, principles for implementation, and concluding recommendations.

9.1 OVERVIEW OF INTERVIEWEES AND INTERVIEW METHODOLOGY

We interviewed congestion experts and officials from multiple levels of government—provincial, municipal, and transit agencies and authorities—with expertise regarding Vancouver, Calgary, Toronto, and Montreal. We also interviewed several Canadian congestion experts not associated explicitly with a single city or region. Interviews focused on the policy priorities and barriers related to congestion and congestion pricing in each region. We conducted a total of 19 semi-structured interviews (18 by telephone; one by email) between January and March 2015. Table 4 shows the list of interviewees. Note that some interviewees wished to remain anonymous.

9.2 INTERVIEW QUESTIONS

Interviews focused on policy priorities, barriers to policy implementation, and opportunities for smart policy. The questions are shown below, but note that our interviews were semi-structured,

Table 4: List of Interviewees

Vancouver	**Chris Quigley**	Senior Planner, TransLink
	Greg Moore	Chair of the Metro Vancouver Board of Directors, Mayor Port Coquitlam
	Kevin Volk & Norm Parkes	British Columbia Ministry of Transportation & Infrastructure
Calgary	**Anonymous**	Alberta Ministry of Transportation
Toronto	**Michael Sutherland**	Director, Economic Analysis & Investment Strategy, Finance, Metrolinx
	Jennifer Keesmaat	Chief Planner, City of Toronto
	Stephen Buckley	General Manager, Transportation, City of Toronto
	Anonymous	*Withheld*
Montreal	**Anonymous**	Government agency in Montreal
	Anonymous	*Withheld*
Other Experts	**Pamela Blais**	Principal, Metropole Consultants Ltd. & Author
	Anonymous	*Withheld*
	Vijay Gill	Assistant Vice-President, North America, CPCS Transcom (formerly Conference Board)
	Anonymous	University of Calgary
	John Lawson	Consultant, Lawson Economic Research (formerly Transport Canada)
	Robin Lindsey	Professor, Operations and Logistics Division, University of British Columbia
	Jean-Philippe Meloche	Professor, Urban Planning Institute, University of Montreal
	Eric Miller	Professor, Civil Engineering, University of Toronto
	Anthony Perl	Professor, Urban Studies and Political Science, Simon Fraser University

[7] Given the Commission's links to McGill University, we used its standard ethics procedures, and gained approval for the research from the university's Research Ethics Board (McGill Research Ethics Board Office, 2015).

and we did not cover each question in each interview; these questions rather served to guide the interviews.

1. Current status:

In your position, what is your involvement in studying and/or developing policies to reduce congestion, in particular pricing policies, and your involvement in governance and policy decision-making around this issue?

2. Local concerns:

What are top policy priorities and objectives in terms of congestion issues in the city(ies) with which you have the most expertise, and why have these risen to the top concerns?

3. Barriers:

What are the three most significant barriers you see (in place or anticipated) to implementing congestion pricing policies and why?

4. Unique:

What makes the city(ies) with which you have expertise unique in terms of congestion problems and potential solutions?

5. How could we help?

Given what you know about our organization, how could Canada's Ecofiscal Commission, dedicated to finding solutions to tough environmental problems, best help the city(ies) with which you have expertise to implement effective and efficient pricing policies to address local congestion problems?

6. Stakeholders

Are there stakeholders we should be aware of to interview or research their positions, and would they likely be supporters or opponents?

7. Timing

What would be the best timing for report, and best help the city(ies) in question to achieve its(their) goals? What is the level of urgency around this issue?

8. Design

Have you thought about the following policy design aspects, and if so, can you offer any thoughts?

- How to use the revenue generated from pricing policies to reduce congestion.
- Potential instruments. Can you rate the following instrument types in terms of potential effectiveness, and potential to implement in the city(ies) in question:

	Appropriate? (1-5)	Implementable? (1-5)
1. Single-entity pricing (e.g., HOT lanes, bridge tolls)		
2. City centre or other cordon pricing		
3. Distance-travelled charges		
4. Parking pricing reform (in particular, demand-based/dynamic parking pricing)		

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